AGRICULTURAL RESEARCH INSTITUTE

PUSA

A

TEXT-BOOK

OF

INDIAN BOTANY

BEING

AN INTRODUCTION TO THE STUDY OF INDIAN BOTANY.

BY

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PREFACE.

When I began teaching Botany in the Hughli College for the B A. Examination in January 1879, I felt the want of a text-book adapted for Indian students. The plants given as examples in the English, American and German text-books are not procurable in India, and thus render these works unsuitable for Indian requirements.

These pages are the result of my leisure hours for four years. Almost everything in this volume is deduced from my own personal experiences.

The brevity required in an introductory treatise will be my excuse if I omit the details necessary for a more accurate knowledge. It would be impossible, even were it desirable, to define, in an elementary work of this kind, every scientific term in use by every writer.

As the object of a study of natural science is the cultivation of the observant faculties in the relation to the phenomena of nature, the specimens for examination, both by the naked eye and by the aid of a microscope, must be readily procurable, otherwise the interest and benefit of the study is lost. From an educational point of view, the value of an acquaintance with natural science lies not so much in the mere accumulation of facts as in familiarity with the methods of scientific investigation. The man who has been well trained in physical science has so great an intellectual advantage over the man who has not been thus trained, that, other things being equal, he will be able to form a sounder judgment, not only on scientific questions, but on things in general.

Sir J. D. Hooker has stated, that "the pupil may well afford to forget all the Botany he has learned, provided only that he retains those habits which it inculcates, of observing accurately, reasoning intelligently, and describing what he has seen more methodically, accurately, and concisely than he would otherwise have done."

Professor Huxley, in an address delivered at Birmingham on 1st October 1880, said, that "the distinctive character of our own times lies in the vast and constantly increasing part which is played by Natural Knowledge. Not only is our daily life shaped by it—not only does the prosperity of millions of men depend upon it, but our whole theory of life has long been influenced, consciously or unconsciously, by the general conceptions of the universe, which have been forced upon us by physical science.

"In fact, the most elementary acquaintance with the results of scientific investigation shows us that they offer a broad and striking contradiction to the opinion so implicitly credited and taught in the middle ages.

"The notions of the beginning and the end of the world entertained by our forefathers are no longer credible. It is very certain that the earth is not the chief body in the material universe, and that the world is not subordinated to man's use. It is even more certain that nature is the expression of a definite order with which nothing interferes, and that the chief business of mankind is to learn that order and govern themselves accordingly. Moreover this scientific 'criticism of life' presents itself to us with different credentials from any other. It appeals not to authority, nor to what anybody may have thought or said, but to nature. It admits that all our interpretations of natural fact are more or less imperfect and symbolic, and bids the learner seek for truth not among words but among things. It warns us that the assertion which outstrips evidence is not only a blunder but a crime."

With reference to the phrase 'applied science,' he stated, —"I often wish it had never been invented, for it suggests that there is a sort of scientific knowledge of direct practical use, which can be studied apart from another sort of scientific knowledge, which is of no practical utility, and which is termed 'pure science.' But there is no more complete fallacy than this. What people call 'applied science' is nothing but the application of pure science to particular classes of problems. It consists of deductions from those general principles, established by reasoning and observation, which constitute pure science. No one can safely make these deductions until he has a firm grasp of

the principles; and he can obtain that grasp only by personal experience of the processes of observation and of reasoning on which they are founded."

The practical benefit derived from the study of the abnormal vital phenomena of plants has, of late years, received a good deal of attention. Sir James Paget recently counselled human pathologists to study the diseases of plants. There, he said, you will be able to study elemental pathology—the pathology of cells and tissues freed from the complexity of a circulating blood and a nervous system.

The greater part of the student's knowledge must always be gained in the field, or with the dissecting knife in hand. Still he will need to be guided by the experience of previous observers, and to be acquainted with the recognised descriptive terms used in his science. It is for these purposes, and not to replace the necessity for observations of his own, that I have introduced the tables given at pages 5, 7, 13, 15, 17, 19, 31, 40, 43, 46, 50, 53, 65, and 67. These tables will also be found useful in describing plants (see p. 71).

With reference to the naming of plants found during excursions (see pp. 286—293). The following works are essential for reference. With regard to flowering plants, consult Roxburgh's Flora Indica, Mr. C. B. Clarke's Edition. Flora of British India, Hooper: "This new work might be supposed to supersede Roxburgh altogether, but I do not think that non-professional Botanists can use a book containing 15,000 species, unless they have many landmarks, both of orders and genera, well fixed in their minds. To search a book of this size for a plant is worse than searching for a needle in a bundle of hay. Now, Roxburgh's book, it has been found by experience, is a useful book for planters and other English denizens who, without being great Botanists, take a sufficient interest in the plants to spend a little time in really working with a book."—Clarke. For the naming of cultivated plants, a manual of gardening by Mr. T. A. C. Firminger will be found useful.

For the purpose of naming non-flowering plants (Ferns), the Synopsis Filicum of Hooker and Baker should be consulted (see pp. 232 and 236). For the naming of Mosses and Liverworts, refer to books mentioned at pp. 246 and 247. No plants are so easy to prepare for the herbarium

as mosses; they easily part with any moisture which they have imbibed; and if common care is used, they are not liable to be spoiled by damp or seriously injured by the depredation of insects.

With regard to the Thallophyta, the English Edition of Sach's text-book (Clarendon Press) should be consulted; also works named on pages 263, 273, and 281.

The tables given at pages 80*g*, 80*k*, 187, 229, 246, 256, and 278 will be found useful by beginners to enable them to get a general idea of the position occupied by the various groups of plants in the vegetable kingdom.

The whole of the present work has been carefully revised by Mr. W. Botting Hemsley, of Kew.

"At the meeting of the British Association at Swansea in August 1879, a new classification of Cryptogams was proposed by Mr. Alfred W. Bennett. He retains Sach's class of Protophyta for the lowest forms of vegetative life: but restores the primary division of the remainder of Thallophytes into Fungi and Algæ, as being more convenient to the student, and at least as much in accordance with probable genetic affinities.

"As regards minor points, the Characeæ are removed altogether from Thallophytes, and again constituted into a separate group of the first rank; Myxomycetes are regarded as presenting a low type of structure, scarcely raised above the Protophyta, and not exhibiting true sexual conjugation; Volvox and its allies are removed from the Zygosporeæ to the Oosporeæ; and the Phæosporeæ are separated off as a distinct order from the Fucaceæ.

"The Thallophytes are, therefore, first of all divided into three primary classes: Protophyta, Fungi, and Algæ. The Protophyta are divisible into two sub-classes, Protomycetes and Protophyceæ. The Protomycetes consist of a single order, the Schizomyces, of which Saccharomyces is regarded as an aberrant form. The Protophyceæ are composed of the Protococcaceæ (including Palmellaceæ and Scytonemeæ), Nostocaceæ, Oscillatorieæ, and Rivularieæ. The Myxomycetes are treated as a supplement to the Protophyta.

"The Fungi are made up of three sub-classes, employing in the main the same characters as Sach's, but in their terminology, using the syllable 'spern' instead of 'spore.'

CONTENTS.

CHAPTER I.

CHAPTER II.

ERRATA.

Page 104, line 5 from bottom, *for* 'black and green tea,' etc., *read* 'The indigenous or hybrid plant makes the best black tea, and the plant produced from seed originally imported from China, the best green tea.'

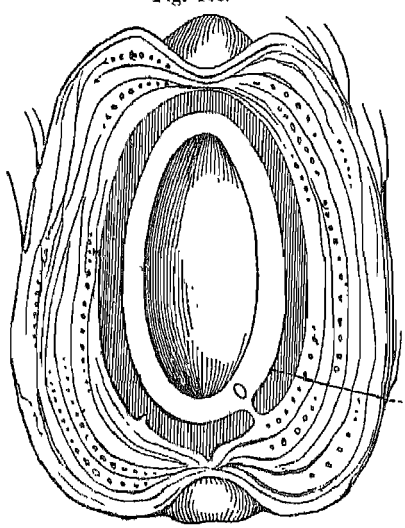
Page 179, line 1, *for* 'Ramex,' *read* 'Rumex.'

MONOCOTYLEDONS.

Flowering plants are classified (see page 80*g*) into two divisions: 1*st*, Angiospermia, in which the ovules are produced in the interior of a structure (the ovary) formed by the cohesion of carpellary leaves; 2*nd*, Gymnospermia, in which the ovules are not enclosed in an ovary. The Angiospermia are again divided into two classes—Dicotyledons and Monocotyledons.

The *seeds of monocotyledons* usually contain a strongly developed endosperm and a comparatively small embryo; these are particularly well seen in large seeds, such as those of Phœnix, Crinum, and Cocos (see Fig. 166). In the Orchideæ and some other orders, the parts of the embryo of the ripe seed are not differentiated.

Fig. 166.

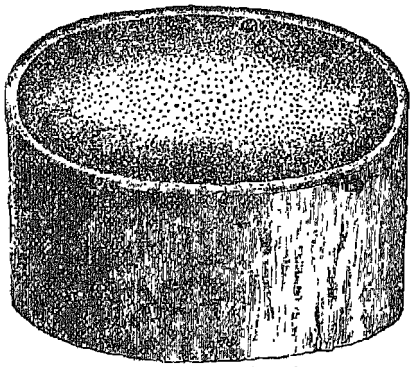


Section of a cocoanut showing the seed *x*, with a minute embryo.

The growth of the primary *roots of monocotyledons* soon ceases, even when they are strongly developed during germination, as in Palmeæ, Liliaceæ, &c.; and secondary roots are developed in their place, which are stronger the higher up they are produced on the axis. In grasses the vascular bundles form a closed hollow cylinder, which at first encloses the central pith.

The plumule of the embryo is usually enclosed in a single sheathing cotyledon, the apex of which usually remains within the seed during germination, and rarely develops into a sheath-like leaf. The axis of the embryo at first takes the form of an inverted cone, dependent on the first formed portions of the stem retaining their original size, while each successive portion is larger; after a time the stem becomes cylindrical. The most striking peculiarity of a cross-section of a *monocotyledonous stem* at first sight is the isolation of the fibro-vascular bundles (see Fig. 167). The fibro-vascular bundles grow outwards crossing the growing cellular tissue (secondary meristem), in which place they branch,—one division, expanding into a number of fibres, enters the leaf through the epidermal layer, the other taking a similar course to the next older bundle. The bundles being of the closed kind, *i.e.*, being incapable of producing new tissue, they acquire their full development before the leaf to which they belong falls; hence, as a general rule, the stems do not increase in diameter to such an extent as they do in dicotyledons.

Fig. 167.



Section of a stem of a palm, showing the isolation of the fibro-vascular bundles.

The bundles formed from the united fibres are most strongly developed at the curved portion towards the centre of the stem; the lower portion of the bundles being expanded into distinct fibres in a manner similar to the upper portion.

The usual *mode of branching of monocotyledons* is monopodial (see modes of branching, page 15), *i.e.*, the generating structure continues to grow at its apex, while lateral structures are given off beneath it; a bud is generally formed in the axil of each leaf, but often does not unfold, so that the number of branches is often less than that of the leaves.

The *foliage leaves of monocotyledons* are commonly arranged alternately in two rows (see Fig. 168); the arrange-

Fig. 168.

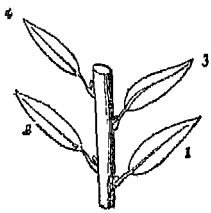
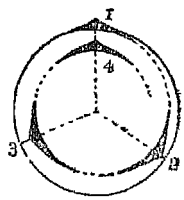


Diagram showing the alternate arrangement of the foliage leaves on the stem, as occurs in many Monocotyledons.

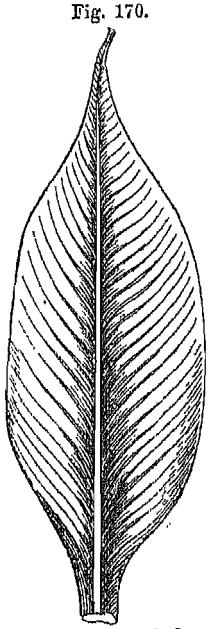
Fig. 169.



Horizontal projection of a cycle of the ½ arrangement of leaves.

ment with the angle of divergence, ⅓rd, is much rarer (see Fig. 169), but occurs in some Cyperaceæ, Pandanaceæ, &c.; in some Musaceæ the angle of divergence is ⅔th: spiral arrangements of foliage leaves are common in Aloe, Palms, &c., &c. The foliage leaves are usually sheathing at the base; this is evidently connected with the want of stipules, which are so frequently found among dicotyledons. The *venation of the foliage leaves* differs from that of most dicotyledons in the veins not generally projecting on the underside of the leaf, but running through the central tissue (or mesophyll); their course, too, is usually parallel, straight, or curved, or when a strong midrib occurs in a broad lamina, as in Musaceæ, &c. (see Fig. 170), the fibro-vascular bundles which go through it give off laterally smaller bundles, which run parallel to one another to the margin of the leaf. It is only rarely that the leaves are netveined, as in Smilaceæ and Dioscoreaceæ.

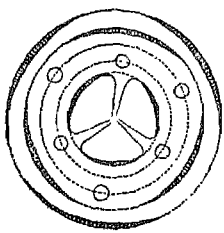
Fig. 170.



Penninerved leaf of *Canna Indica*.

The *flowers of most monocotyledons* consist of five alternating whorls (see Fig. 171), each with an equal number of members, *viz.*, an outer and inner perianth whorl, an outer and inner whorl of stamens, and a carpellary whorl. There are usually three members in each whorl. The two whorls of members of the perianth are commonly similar in form and colour; hence they are not usually distinguishable as calyx and corolla; sometimes, however, the outer perianth whorl is green and sepaloid, and the inner whorl larger and petaloid, as in Alisma, Tradescantia, &c. The stamens of monocotyledons scarcely ever branch as is often the case in dicotyledons.

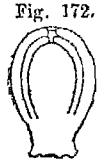
Fig. 171.



Floral diagram of a typical monocotyledon, as occurs in *Liliaceæ*; representing a flower consisting of five alternating whorls, each with three members, of which the two outer ones constitute the perianth, the two next the andrœcium, and the middle one the gynœcium.

Adhesion of the perianth and stamens occurs much less constantly in particular families among monocotyledons than among dicotyledons. The prevailing form of the

Fig. 172.

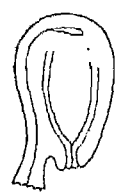


Orthotropous ovule as in Smilaceæ.

Fig. 173.

Campylotropous ovule as in some Scitamineæ.

Fig. 174.



Anatropous ovule as in Gramineæ.

ovule is anatropous, as in Gramineæ (see Fig. 174); in some Scitamineæ, &c., the ovules are campylotropous (see Fig. 173); in Smilaceæ and a few Aroideæ, &c., the ovules are orthotropous (see Fig. 172).

ABSTRACT OF MONOCOTYLEDONOUS ORDERS.

The arrangements of monocotyledons lately made by Mr. Bentham is here adopted. He divides the whole class into four series. The two first series, Epigynæ and Coronarieæ, include flowers with a double, usually petaloid, perianth, and with a syncarpous ovary. The position of the ovary serves to distinguish the two series; in the 1*st*, Epigynæ, it is inferior; in the 2*nd*, Coronarieæ, it is superior. The ovary in the 3*rd* series, Nudifloræ, is mostly apocarpous; and the ovary of the 4*th*, Glumales, is always uniovular.

MONOCOTYLEDONS.

- Epigynæ ...
  - Hydrocharideæ: Ex., Vallisneria.
  - Scitamineæ: Ex., Plantain.
  - Orchideæ: Ex., Orchids.
  - Burmanniaceæ: Ex., Burmannia.
  - Irideæ: Ex., Gladiolus.
  - Amaryllidaceæ: Ex., Crinum.
  - Taccaceæ: Ex., Tacca.
  - Dioscoreæ: Ex., Yam.
  - Bromeliaceæ: Ex., Pineapple.
- Coronarieæ ...
  - Roxburghiaceæ: Ex.
  - Liliaceæ: Ex., Onion.
  - Smilaceæ: Ex., Smilax.
  - Pontederaceæ: Ex., Pontedera.
  - Commelinaceæ: Ex., Tradescantia.
  - Xyrideæ: Ex., Xyris.
  - Juncaceæ: Ex., Rush.
  - Palmeæ: Ex., Palms.
- Nudifloræ ...
  - Pandanaceæ: Ex., Screwpine.
  - Aroideæ: Ex., Caladium.
  - Typhaceæ: Ex., Elephant grass.
  - Pistiaceæ: Ex., Duck-weed.
  - Naidaceæ: Ex., Potamogeton.
  - Alismaceæ: Ex., Sagittaria.
- Glumales ...
  - Eriocauloneæ: Ex., Eriocaulon.
  - Cyperaceæ: Ex., Sedges.
  - Gramineæ: Ex., Grasses.

SERIES I.—*Epigynæ.*

Flowers with a double, usually petaloid, perianth; ovary usually inferior, syncarpous.

Order I, Hydrocharideæ.—Are aquatic herbs, with usually unisexual regular flowers issuing from a spathe at the end of the scape-like peduncles. Example: Hydrilla verticellata.

Order II, Scitamineæ.—Are herbs with irregular bright coloured flowers; stamen 1 (in the Suborder Museæ there are 5 fertile stamens). Example: Plantain, Ginger, Arrow-root.

Order III, Orchideæ.—Are herbs with irregular flowers; stamen usually 1, rarely 2 gynandrous, pollen cohering into waxlike or mealy masses (pollinia). Example: Vanda.

Order IV, Burmanniaceæ.—Are herbs with grass-like or scale-like leaves; flowers regular, hermaphrodite; perianth bright coloured; stamens, 3 introrse, or 6 extrorse. Example: Burmannia disticha.

Order V, Irideæ.—Are herbs, with a 6-parted petaloid perianth; stamens 3; anthers extrorse; stigmas 3, often petaloid. Example: Pardanchus chinensiæ (Das-báhú).

Order VI, Amaryllidaceæ.—Are herbs, with a 6-leaved petaloid perianth; stamens 6, inserted on the perianth-tube; anthers introrse. Example: Crinum Asiaticum (Barakánár).

Order VII, Taccaceæ.—Are perennial herbaceous plants, with radicle leaves and regular hermaphrodite flowers in umbels or long scapes; perianth petaloid; stamens 6, with petaloid filaments; ovary 1-celled, with 3 parietal placentas. Example: Tacca primatifida.

Order VIII, Dioscoreæ.—Plants with twining stems and net-veined leaves; flowers regular, diœcious. Example: Dioscorea globosa (Chupri-álú).

Order IX, Bromeliaceæ.—Are herbs, with fleshy or dry crowded leaves sheathing at the base; perianth in two circles differently coloured; stamens 6; ovary sometimes superior, 3-celled. Example: Bromelia ananas, L.

Series II.—*Coronariæ.*

These plants have flowers with a double, usually petaloid, perianth; ovary superior, almost always syncarpous.

Order I, Roxburghiaceæ.—Are twining shrubs with 4-merous flowers; ovary 1-celled; stigma sessile. Example: Roxburghia.

Order II, Liliaceæ. — Are herbs, with parallel-veined leaves and regular 6-androus flowers; anthers introrse; ovules anatropous or amphitropous. Example: Allium cepa (Onion).

Order III, Smilaceæ.—Are herbs or climbing shrubs, with net-veined leaves and regular hermaphrodite or dicœcious flowers; ovules orthotropous. Example: Smilax.

Order IV, Pontederaceæ.—Are aquatic herbs, with perfect, more or less irregular, blue flowers enclosed in a spathe; perianth-segments all petaloid. Example: Pontederia vaginalis.

Order V, Commelinaceæ.—Are herbs, with jointed, often branching, leafy stems and irregular perfect flowers; outer leaves of perianth sepaloid, inner petaloid, each of three parts. Example: Commelina communis.

Order VI, Xyrideæ.—Are sedge-like herbs, with flowers in scaly heads; stamens 3; anthers extrorse; perianth-segments 6, outer scarious; ovary 1-celled. Example: Xyris indica.

Order VII, Juncaceæ.—Are herbs of a sedgy or grass-like appearance, with often capitate inflorescence; perianth of six similar scale-like pieces; stamens 6, rarely 3. Example: Flagillaria indica (Ban-chándar).

Order VIII, Palmeæ.—Are usually arborescent plants, with simple unbranched stems, bearing large terminal clusters of mostly compound or deeply divided stalked leaves; flowers hermaphrodite or unisexual on a simple or branched padix enclosed in a one or many valved spathe. Example: Cocos nucifera.

Series III.—*Nudiflorœ.*

Flowers usually achlamydeous, with a dry scarious perianth; ovary mostly apocarpous.

Order I, Pandanaceæ.—Are trees or shrubs; with long, narrow leaves, imbricated in three spiral rows; flowers unisexual or polygamous, arranged on a simple or branched spadix, furnished with numerous spathe-like bracts; perianth none or consisting of a few scales. Example: Pandanus odoratissimus.

Order II, Aroideæ.—Are plants, with usually net-veined leaves; flowers mostly monœcious, sessile, arranged on a spadix; perianth wanting, or of 4 to 6 scales. Example: Colocasia antiquorium.

Order III, Typhaceæ.—Are marsh herbs, with linear leaves and monœcious flowers, arranged on a spadix or in

heads; perianth none or reduced to a whorl of hairs; ovary solitary, 1-celled. Example: Typha elephantina (Hogla).

Order IV, Pistiaceæ.—Are plants floating free on water, having one female and several male flowers within each spathe. Example: Pistia stratiotes.

Order V, Naidaceæ.—Are slender floating or submerged plants, with jointed stems and long leaves; flowers inconspicuous, hermaphrodite, monœcious or dicœcious; perianth of from 1 to 4 scaly pieces or none. Example: Potamogeton indica.

Order VI, Alismaceæ.—Are aquatic plants, mostly with broad petiolate leaves and scape-like flowering stems; flowers in umbels, racemes, or panicles, perfect or monœcious; perianth of six pieces. Example: Sagittaria (Chotakat).

Series IV.—*Glumales.*

Perianth replaced by membranous scales; ovary always uniovulate or with uniovulate loculi.

Order I, Eriocauloneæ.—Are aquatic or marsh herbs, with grass-like leaves; flowers arranged in dense heads, monœcious, sometimes dicœcious; perianth glumaceous; ovary 1 to 3-celled. Example: Leucocephala graminifolia.

Order II, Cyperaceæ.—Are grass-like herbs, with fibrous roots, and solid, frequently angular, stems; leaf-sheaths tubular, closed, without ligules; flowers perfect or unisexual. Example: Cyperus rotundus (Mútha).

Order III, Gramineæ.—Are mostly herbaceous plants, rarely arborescent, usually with cylindrical hollow jointed stems, and narrow alternate leaves, with tubular sheaths, split down at the side, opposite to the blade, often with a ligule at its summit; flowers usually hermaphrodite, sometimes monœcious or polygamous. Example: Rice and Bamboo.

Details of Monocotyledonous Orders.

Hydrocharideæ

Are aquatic herbs, with usually unisexual regular flowers, issuing from a spathe at the end of the scape-like peduncles;

the perianth consists of one or two whorls, the inner, when present, petaloid; ovary inferior; seeds without endosperm.

The combination of the characters of this order serves to distinguish it from all other monocotyledons, while the characters taken separately connect it with many.

Hydrilla verticellata is a submerged water plant with filiform jointed stems, sometimes creeping, sometimes floating below the surface of the water; leaves sessile, verticillate; flowers small, white, axillary. This plant is used by sugar-refiners for the purpose of purifying sugar; the moisture which it contains slowly percolates through the sugar, carrying off impurities.

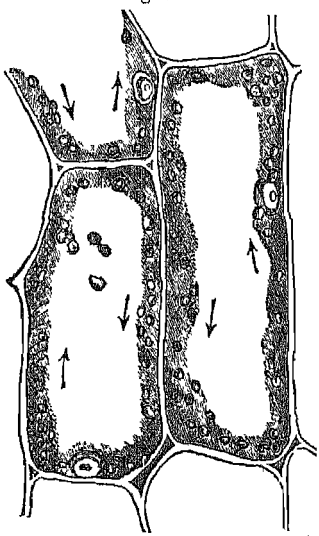
Fig. 175.

Plants of *Vallisneria spiralis* (reduced).

Vallisneria spiralis (see Fig. 175) is a submerged water plant, with radicle grass-like leaves; it grows abundantly in fresh water tanks; the female flowers are borne upon long spirally-twisted peduncles, which permit them to reach the surface, where they come into contact with the detached floating male flowers.

V. octandra (Sheyálá) is also very common; also *V. alternifolia* (Rasnajhanji). *Ottellia alismoides* (Pani-kalá) is an aquatic annual, with radical, petiolate, cordate, waved leaves and whitish flowers, which appear during the rains; capsule oblong, six, grooved, crowned with the withered perianth.

Fig. 176.



Cells from the leaf of *Vallisneria spiralis*; the round bodies are grains of chlorophyll, the arrows denote the direction of the currents of protoplasm (after *Thomé*).

The submerged leaves of several species of this order are well suited to show the rotation of the cell-sap (see Fig. 176).

Scitamineæ

Are herbs, often very robust, and sometimes arborescent, having large leaves and irregular, usually brilliantly-coloured, flowers; fertile stamen 1 (or 5 in the Suborder Musaceæ), with five petal-like staminodes; ovary inferior, 3-celled.

This order is usually divided into three suborders: *Zingiberaceæ*, *Marantaceæ*, and *Musaceæ*. The Suborder *Zingiberaceæ* is distinguished from the other two by the fertile stamen being posterior, and the anther 2-celled, and by the embryo being contained in a special sac or vitellus. Suborder 2, *Marantaceæ*, has the outer circle of stamens more or less developed in a petaloid form, and but one lateral stamen of the inner circle fertile. Suborder 3, *Musaceæ*, has usually five fertile stamens. From the great prevalence of these plants in the Indo-Malayan region, and also in the neighbouring islands of Java, Borneo, New Guinea, &c., this region has received the name of the "*Region of the Scitamineæ*." The principal plants of the suborder of Zingiberaceæ are *Zingiber officinale* (Adrúk, adá): it is universally cultivated in India for the sake of its rhizomes, the flowers are small whitish purple, and appear in the rains. *Curcuma longa* (Haldi) is likewise cultivated all over India; the flowers are large yellowish white, and appear in the rains. *C. amada* has small yellowish white flowers, which appear during the rainy season; the fresh root has the smell of a green mango. *Amomum carda-*

momum has flowers of a light rose colour, tinged with yellow, which appear in April; the seeds are agreeably aromatic.

Elettaria cardamomum (Elachi), the seeds of which are commonly known as cardamoms. *Hedychium coronarium* (Dulál-chámpá) is a native of various parts of Bengal; it flowers during the rains; the flowers are handsome, large, pure white, and very fragrant; it is the most charming plant of this order. *Costus speciosus* is a native of moist shady places; it flowers during the wet season.

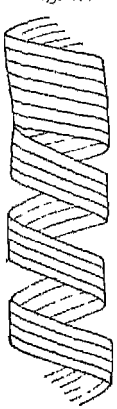
The principal plants of the Suborder *Marantaceæ* are *Maranta arundinacea* (Arrowroot); its flowers are pure white and appear in the rains; arrowroot is prepared from the rhizomes by maceration in water.

M. dichotoma (Múktapátí) is a native of various parts of India; flowering time the hot season. Mats made of the split stems (sital-páti) are smooth and particularly cool; they are in general use everywhere in India.

Canna Indica (Indian shot), common over India; it is in flower and seed most part of the year; there are two common varieties—one with red, the other with yellow, flowers.

The principal plants of the Suborder Musaceæ are *Musa paradisiaca*, indigenous in the forests of Chittagong and Cachar; the number of cultivated varieties is very large.

Fig. 177.



Spiral thickening of a vessel from a leaf of the plantain (magnified).

Fig. 178.

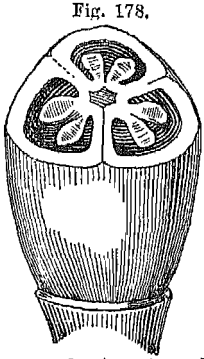
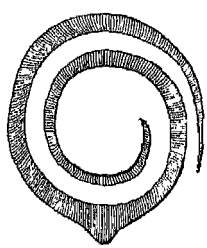


Diagram showing the multilocular compound ovary of the plantain.

Fig. 179.



Convolute vernation of a leaf of the plantain.

The fibres of the petioles of *M. textilis* is known as Manilla hemp. Spiral vessels can be well seen by examining a portion of the leaf of the common plantain under the microscope (see Fig. 177).

Other genera are: *Kampfera*, L.; *Alpinia*, L.; *Globba*, L.; *Phrynium*, Willd.; *Calathea*, Meyr.; *Heliconia*, L.; *Ravenala*, Adans.

Fig. 180.

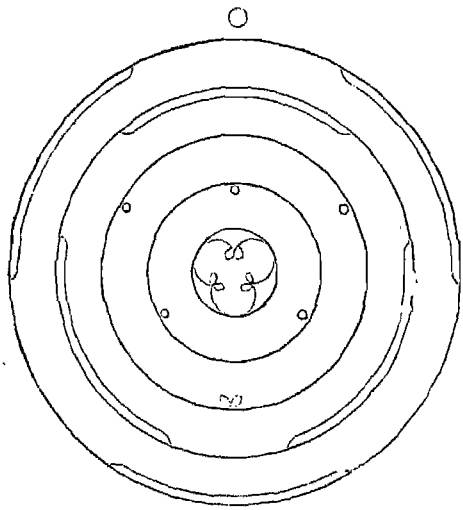


Diagram of the flower of an Orchid.

The flowers of Orchideæ can be derived from the type represented in Fig. 171, although their external form is so remarkably different; of the androecium only a single stamen is completely developed in most orchids, *viz.*, the anterior one of the outer whorl, the others being abortive.

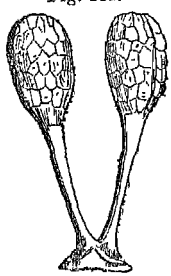
Orchideæ

Are herbs, with regular flowers; perianth in two whorls; stamen 1 (or 2 in the tribe Cypripedieæ) gynandrous; pollen cohering into wax-like or mealy masses; ovary inferior, 1-celled, with parietal placentas; seeds extremely numerous and small.

The suppression of 2 out of 3 stamens connects this order with Marantaceæ and Zingiberaceæ. The orchids, however, differ very considerably from all other monocotyledons;—1*st*, in the usually great irregularity of the perianth, especially in the posterior member of the inner circle (the labellum; frequently anterior by the twisting of the ovary), which is sometimes developed into a spur or nectary; 2*nd*, in the filament being coherent with the style forming

the column; *3rd*, in the ridges occurring in the column and labellum, which are believed to be abortive stamens, giving rise to the opinion that the elements of two circles of stamens exist in this order, of which five are usually suppressed; *4th*, in the prolongation of the upper edge of the stigma (*the rostellum*); *and 5th* and lastly, in the pollen being less developed than usual; the process of sub-division into distinct pollen-grains being arrested, so that it remains in masses (*pollinia*) (see Fig. 181) sometimes provided with a pedicel or *caudicle*, which adheres to a *gland* or glands at the apex of the stigma. The lobellum, rostellum, and caudicle are sometimes endowed with contractile properties. The Orchideæ are terrestrial in temperate climates; in warm and moist climates they are frequently epiphytic, hanging on the branches of trees, or even attaching themselves to rocks, &c. They are most abundant in damp situations.

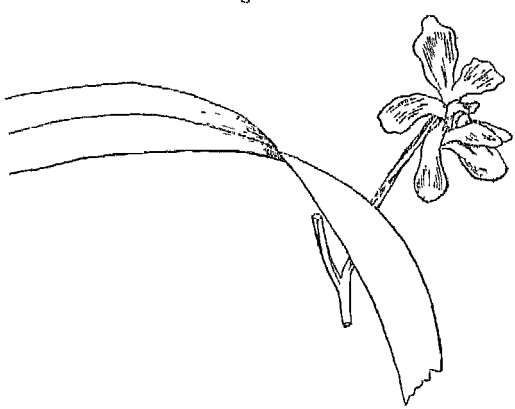
Fig. 181.



Pollinia with caudicles and gland (magnified).

The following classification of the genera in tribes has lately been proposed by Mr. Bentham, in the journal of the Linnean Society:—

Fig. 182.



Flower and portion of a leaf of *Vanda*.

Tribe 1, *Epidendreæ*.—Anther 1; dorsal operculate, usually incumbent, with the cells distinct and parallel; pollinia waxy, in one or two series parallel, two or four in each series (1—4 in each cell), free or joined in each cell by a viscous substance or a granular appendage, very rarely attached to the rostellum.

This tribe is formed by the union of Lindley's Malaxideæ and Epidendreæ, which he had distinguished by the absence or presence of a caudicle to the pollen masses; but this character is very obscure in many genera.

Mr. Bentham divides this tribe into nine subtribes, based mainly on the vegetative characters and the number of pollinia. The subtribe Dendrobiæ is the most profusely represented in India, especially the large genus Dendrobium, which numbers some three hundred species, ranging from India and Japan to Australia and New Zealand. D. Pierardii is one of the commonest orchids in the plains of Bengal, growing generally on mango trees: it has jointed stems, 2 to 5 feet long; alternate, sessile, oblong lanceolate leaves, and large showy yellowish white flowers, issuing from the nodes of the stem. The subtribe Cœlogyneæ is also largely represented in India. Several handsome species of the genus grow on rocks in the Himalayas at an elevation of 4,000 to 8,000 feet.

Tribe 2, *Vandeæ*.—Anther 1; dorsal operculate, lying upon or against the rostellum, with the cells very often confluent during flowering; pollinia waxy, very often 2, obliquely or transversely grooved, or 4, in pairs, fore and aft; anther-case deciduous; pollinia with a gland or plate constituting the pollinarium. This tribe is again divided into eight subtribes, whereof the Sarcantheæ are the most numerous and conspicuous in India. Vanda teres, V. Roxburghii, and Saccolabium guttatum are common examples in Bengal. The first grows only in the grass of the Sunderbuns; and the second is very common on mango and other trees: it has dusky, ferruginous flowers, with a mixture of yellow and white, produced during the rainy season. The Saccolabium grows on trees in the tidal swamps.

Tribe 3, *Neottieæ*.—Anther 1; dorsal operculate or erect and persistent, with distinct parallel cells; pollinia granu-

lar or powdery; stems not thickened into pseudobulbs. With this Mr. Bentham combines Lindley's Arethuseæ.

Tribe 4, *Ophrydeæ*.—Anther 1; dorsal erect, prone or reflexed, with distinct, parallel or divergent cells, adnate to the anther-bed, and often continued at the base into the rostellum; pollinia granular, produced downwards in each cell into a caudicle.

Platanthera susannæ and several species of Habenaria represent this tribe, which consists almost entirely of ground-orchids.

Tribe 5, *Cypripedieæ*.—Anthers 2, sessile at the sides of the rostellum, or stalked.

The genus Cypripedium is represented by three or four species in Assam. They are ground-orchids, remarkable for their large slipper-shaped labellum.

Aspostasia has been regarded as a separate order, but like some other Cypripedieæ it only differs from the bulk of orchids in having a 3-celled ovary.

Amaryllideæ

Are herbs having leaves with veins diverging from the base and parallel to the mid-rib, with a 6-leaved petaloid perianth and 6 stamens; ovary inferior, 3-celled.

This epigynous order contrasts with the hypogynous Liliaceæ.

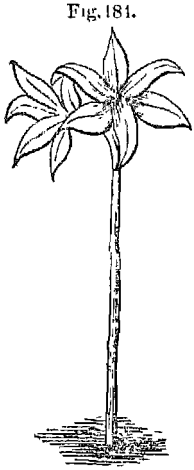
The order includes many ornamental species prized in gardens. *Crinum Asiaticum* (Bara kánur) (see Fig. 183) is a large bulbous herb common in gardens, with smooth, linear, lanceolate radicle leaves and large umbels of regular white flowers, which appear during the wet season, and more or less the whole year. In this species the bulb is often prolonged above the surface of the ground, so as to form a short trunk. *Amaryllis grandiflora* is common in gardens; the flowers are large flesh-coloured.

Agave Americana is now naturalized in most parts of India; preparations of the root are used medicinally by the Mexicans. *Curculigo orchioides* is a small plant common in most parts of India; the roots are tuberous, about 4 inches long, having a slightly bitter taste; they are used in medicine. (This differs from the normal Amaryllidaceæ in

Fig. 183.

Crinum Asiaticum, reduced (after *Oliver*).

Fig. 184.



Scape of *Amaryllis* with 2 flowers.

having a 1-celled ovary with three parietal placentas, and is usually referred to the Hypoxideæ, which some botanists regard as an independent order, while others would class them as a suborder of the present order.)

Dioscorideæ

Are plants with twining stems (see section stems, page 12) and net-veined leaves; flowers regular, dioecious; stamens 6; ovary 3-celled.

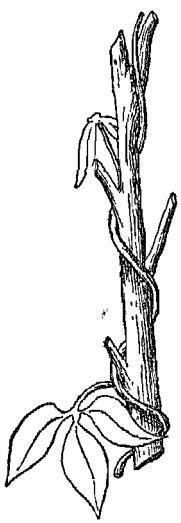
The twining habit and net-veined leaves distinguish this order from the Amaryllidaceæ. *Dioscorea globosa* (Chupri-

Fig. 185.

Versatile anther of *Amaryllis*.

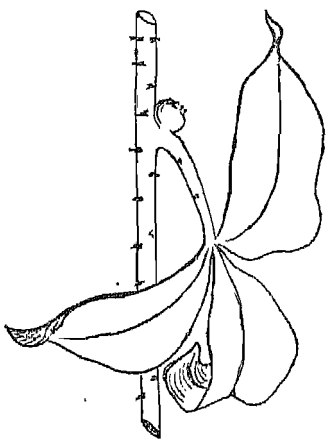
álú) is the most esteemed of all the yams; the tubers are roundish white; the stems twine to the right (dextrorse) like the English hop; the leaves are alternate and opposite cordate, and the flowers are small white; they appear during the rains. *D. alata* (Kham álú) is also much cultivated; the stems twine as in D. globosa; flowering time the close of the rains: the tubers are sometimes of great size. *D. rubella* (Garaniya álú) is also commonly cultivated. There are several other common species. Minute green bulbils are often borne in the axils of the leaves of some species of Dioscorea (see section stem, page 16).

Fig. 186.



Climbing stem of *Dioscorea*, twining to the right.

Fig. 187.

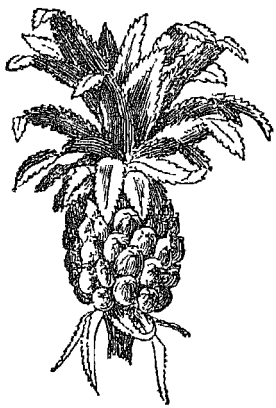


Portion of stem of Dioscorea, with a bulbil in the axil of the leaf.

Bromeliaceæ

Are herbs, with fleshy or dry crowded leaves, sheathing at the base, usually covered with scales; the parts of the outer whorl coherent, of the inner distinct; stamens 6; ovary 3-celled, free or adherent.

Fig. 188.



Polythalamic fruit (Sorosis) of *Ananas sativus*.

Many of the Bromeliaceæ have free ovaries. The Bromeliaceæ are wholly American, and the only plant of this order common in India is *Ananas sativus* (see Fig. 188); which flowers about the beginning of the hot season. This plant is important, not only on account of its delicious fruit, but also on account of the fibres, which abound in the leaves; from which cloth has been manufactured as fine as muslin. Most of these plants are epiphytic, appearing to be capable of obtaining the greater part of their nourishment from the atmosphere.

Fig. 189.

Petaloidperianth of a Lily.

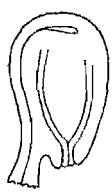
Liliaceæ

Are herbs, with parallel veined leaves and regular 6-androus flowers; anthers introrse; perianth petaloid, 6-merous; ovary 3-celled with central placentation; ovules anatropous; seeds with fleshy endosperm.

Fig. 190.

Orthotropous ovule as in *Smilaceæ*.

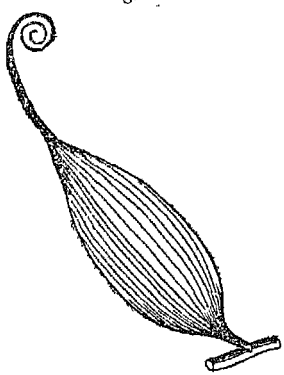
Fig. 191.



Anatropous ovule as in *Liliaceæ*.

The Liliaceæ have widely spreading relations, although the typical forms are at once distinguishable; the superior ovary separates them from Amaryllidaceæ: the tribe Asparageæ closely resembles the Smilaceæ in appearance and general character; all the Liliaceæ, however, have anatropous or amphitropous ovules; whereas in Smilaceæ the ovules are orthotropous.

Fig. 192.

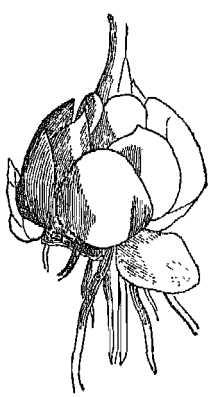


A curvinerved leaf, ending in tendril, of *Gloriosa superba*.

Gloriosa superba (Ulát-chandál) has a climbing herbaceous stem; the midribs of the leaf terminate in tendrils (see Fig. 192); the flowers are large, and the style has a peculiar sensitive motion; these plants appear during the rainy season.

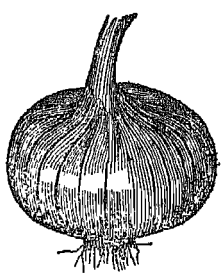
Lilium longifolium is a common garden plant; the flowers are large white and fragrant, and appear about March. *Polianthes tuberosa* (Rajaní gandhá) is a common garden perennial, celebrated for the fragrance of its large white flowers. The leaves of *Sanseviera Roxburghiana* (Múrbá) yield the tenaceous fibre, termed bowstring hemp. *S. guineensis* and *S. capensis* are common in gardens. The former has peculiar dark green ribbed horn-like leaves.

Fig. 193.



Scaly bulb of Lily.

Fig. 194.

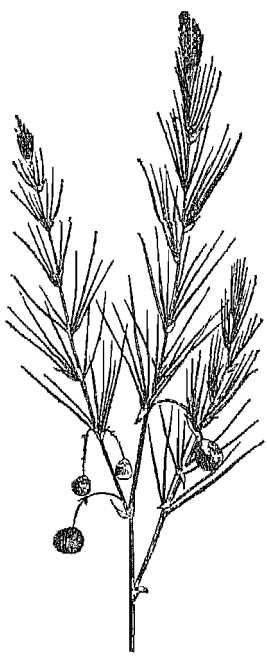


Tunicated bulb of Onion.

Aloë perfoliata (Ghrito kumárí) is common in dry situations. *A. soccotrina* and *A. vulgaris* are used medicinally. *Yucca gloriosa* has strap-shaped, sharp-pointed leaves and greenish white flowers.

Allium sativa (Rashun) is cultivated in gardens; the flowers are small white. *A. cepa* (Peyaj) (see Fig. 194) is largely cultivated everywhere; the flowers are small, white, and appear in the cold season. *Asparagus officinalis* (Hillúá) (see Fig. 195) is cultivated in gardens; the flowers are of a yellowish green colour, and appear in March and April.

Fig. 195.



Portion of a branch of Asparagus.

A. racemosus (Sat-múlí) is a scandent, slender, shrubby plant, a native of various parts of India. Flowering time the cold season; the flowers are pure white, and delightfully fragrant.

Urginea maritima is the medicinal squill, valuable as an expectorant and diuretic. *U. indica* inhabits the sandy shores of the peninsula of India. The bulb is used for the same purpose as that of *U. maritima*.

The bulbs of *Ledebouria hyacinthoides* grow in sandy plains, in many parts of India, and resemble squills in general appearance, but are of a smaller size. *Peliosanthes teta* is a perennial plant, with plaited radical leaves and small green flowers.

Other genera are: *Dracæna, Cholchicum, Hyacinthus,* &c.

Smilaceæ

Are herbs or climbing shrubs, with net-veined leaves and regular hermaphrodite or dicœcious flowers; perianth from 6—10 parted; ovary superior, from 3—5-celled; ovules orthotropous; seeds with hard, fleshy endosperm.

These plants differ from those of Liliaceæ, in having net-veined leaves, climbing stems, mostly small dicœcious flowers, and orthotropous ovules. In foliage and habit they closely resemble the Dioscoreæ, from which they are easily distinguished by their superior ovary, and as far as the Indian genera are concerned, by their baccate fruit. *Smilax ovalifolia* (Kúmáriká) is common in hedges and wild places. The stems are round, the leaves oval, smooth, from 5—7-nerved; the flowers are small, and of a greenish colour; they appear during the hot season. Sarsaparilla, used in medicine, is the dried root of *Smilax officinalis*. The roots of *S. lanceæfolia* and *S. glabra* are used in this country medicinally in cases of rheumatism, &c.

Pontederiaceæ

Are aquatic herbs, with perfect more or less irregular flowers, sometimes subtended by a spathe; the perianth is persistent, petaloid, 6-merous, rolling inwards after flowering; stamens 3—6, mostly unsymmetrical; ovary superior, 3-celled; seeds with mealy endosperm.

This order is separated from Liliaceæ chiefly by its irregular flowers, by the persistent perianth rolling inwards after flowering, and by the mealy endosperm of its seeds.

Pontederia vaginalis (Nauká) is a native of the borders of tanks and marshy places; it flowers during the rains; leaves radicle, narrow, cordate, entire, smooth; flowers blue. The order is a very small one. The plants are chiefly confined to the stagnant waters of hot countries.

Commelinaceæ

Are herbs, wth jointed, often branching, leafy stems, perfect flowers, clustered within one or two large concave bracts; outer leaves of perianth sepaloid, inner petaloid, each of three parts; stamens 6, all fertile or some abortive, often peculiar in form; ovary superior, from 2—3-celled; seeds with fleshy endosperm.

The jointed stem and the outer sepaloid perianth-segments serve to distinguish these plants from their nearest allies. *Commelina communis* (Jatá kánchará) is common over the low moist parts of India; flowering during the rainy season. The leaves are ovate, lanceolate, acute with waved margins, and involucres many flowered.

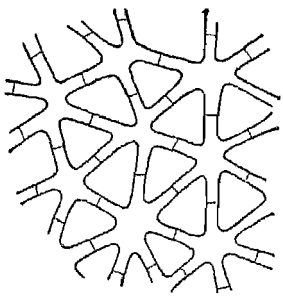
C. bengalensis (Kanchará) is smaller and not so common as the last mentioned species; the leaves are alternate, cordate, hairy; the involucres are 3-flowered; the flowers are small and bright blue. *Tradescantia discolor* is a common garden plant, about 2 feet in height, with sharp pointed leaves, of a green colour, bordered with reddish purple; flowers small, white. The protoplasm, nucleus, rotation of the cell-sap, etc., are well seen in the moniliform hairs of the stamens of this plant. *Cyanotis axillaris* (Bághanulá) is an annual creeping plant with axillary flowers, a native of moist pasture ground, borders of rice-fields, &c.; appearing and flowering during the wet and cold season.

Juncaceæ

Are herbs of a sedgy or grass-like appearance, with hollow or transversely divided, rarely flat, leaves, and often capitate inflorescence; perianth regular, persistent, of six dry or scarious segments; stamens 6; ovary superior, from 1—3-celled; seeds with fleshy, horny endosperm.

The sedge-like habit of these plants and the scarious nature of the segments of the perianth distinguish them from Liliaceæ. *Flagellaria indica* (Ban-chándar) is a long straggling prennial plant, flowering during the early part of the rains; flowers are small, white. *Juncus bufonius* is a small tufted annual plant with inconspicuous flowers, scattered along the stems. The Juncaceæ is a large order; the species are chiefly natives of cold and temperate regions. The tissue of the leaves has a beautiful microscopic structure, being formed of stelliform cells (see Fig. 196).

Fig. 196.

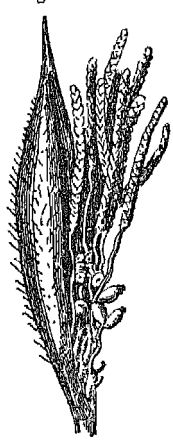


Stellate cells from a leaf of *Juncus* (magnified).

Palmeæ

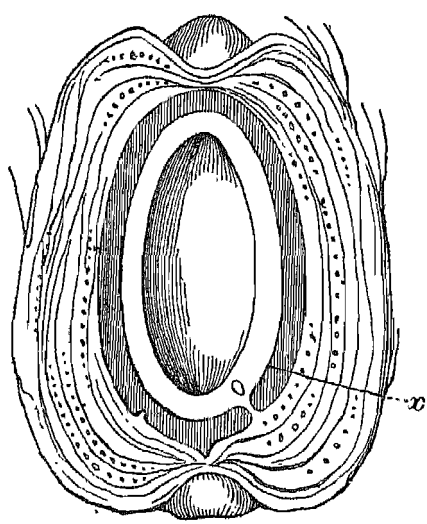
Are woody, arborescent trailing or climbing plants, usually with a simple unbranched stem, bearing scattered or large

Fig. 197.



Compound spadix and spathe of a Palm.

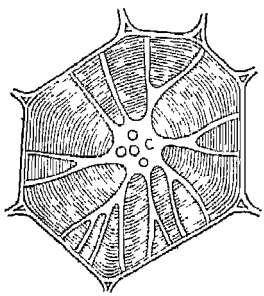
Fig. 198.



Section of a Cocoanut.

terminal clusters of mostly deeply, palmately or pinnately divided, rarely compound, petiolate leaves; flowers usually diclinous and often dicœcious, sometimes hermaphrodite on a simple or branched spadix (see Fig. 197), enclosed in a one or many valved spathe; perianth 6-leaved in two circles; stamens usually 6; ovary from 1—3-celled with fleshy or hard, often ruminated, endosperm in which the minute embryo is superficially embedded (see Fig. 198).

Fig. 199.



Cell from the shell of a cocoa-nut showing the excessive thickening of the cell-wall (magnified).

The fruit in Cocos and Areca is 1-celled from the suppression of two of the carpels; it is 3-celled in Borassus, Caryota, Calamus, Arenga, etc.

The structure of the pericarp is particularly variable: in Cocos the epicarp is fibrous, affording the coir of commerce; the endocarp is a hard shell and is used for various purposes (see Fig. 199). In Phœnix the endocarp is fleshy and sweet.

This order is a very large one, and constitutes one of the most striking features in the vegetation of most tropical regions. It consists of upwards of 100 genera, embracing about one thousand species, only about half-a-dozen of which occur in temperate regions; many of them yield useful products, and some of them supply nearly all the wants of the inhabitants of certain countries.

These plants form a very natural group, separated by distinct characters from the rest of the monocotyledons. There is a connection with some of the Aroideæ and Liliaceæ, but the habit and position of the embryo at once distinguishes them. *Areca catechu* (Guya, súpárí) is one of the handsomest palms in India; it flowers during the hot season; the flowers are monœcious. The endosperm is ruminated (Betel nut).

Borassus flabelliformis (Tál).—This palm is common all over India; it flowers during the hot season; the flowers are dicœcious; the leaves are employed for making punkahs;

and the wood is used for various purposes. The fruit is drupacious. *Phœnix sylvestris* (Khájúr) is common all over India: the juice (Tári) of the tree is usually boiled down into sugar; the flowers are dicœcious. *P. dactylifera* is the date tree.

Cocos nucifera (Narikel): flowers during the hot season; it is largely cultivated for its fruit.

Calamus rotang (Bet) is a dicœcious plant; the fruit is covered with numerous hard imbricated scales; the flexible stems of this and other species are largely exported from the Malayan peninsula for canework.

Caryota urens is common on the westerm coast of the Madras peninsula; it has compoundly segmented leaves, and an inferior sort of sago is prepared from the pith.

Other genera are: *Oreodoxa, Arenga, Zalacca, Sagus, Corypha, Chamærops,* &c.

Pandanaceæ

Are trees or shrubs, often branching; leaves imbricated in three spiral rows, mostly linear lanceolate; flowers unisexual or polygamous, arranged on a very dense, simple or branched, spadix, furnished with numerous spathe-like bracts; male inflorescence usually branched, female inflorescence simple; perianth none, or consisting of a few scales; stamens numerous; ovary 1-celled; seeds with the minute embryo embedded near the base of the fleshy endosperm.

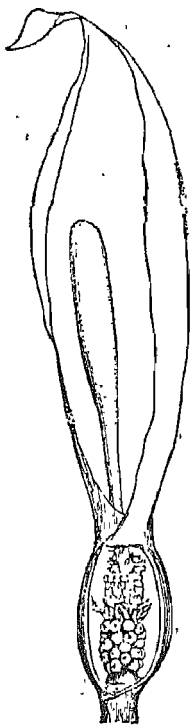
The branching stem and large aërial roots distinguish Pandanaceæ from Palms. The narrow undivided leaves are spirally developed on the stem; hence the name Screwpines, by which they are commonly known. *Pandanus odoratissimus* (Keyá) attains to the height of about 15 feet, the stem at half that height branching into several sub-erect arms terminated by thick foliage; it flowers chiefly during the rainy season. The flowers are dicœcious, small, and delightfully fragrant. *Pandanus fœtidus* (Keyá-kántá) is sometimes used for making hedges; it flowers during the cold season. *Nipa fruticans* grows abundantly in the Sunderbunds: it is regarded by some botanists as the type of a distinct order, having the pinnate leaves of a Palm and the inflorescence of a Pandanus.

Aroideæ

Are plants, with usually net-veined, often divided leaves; flowers monœcious, more rarely dicœcious, or sometimes bisexual, usually sessile on a spadix, enclosed in, or subtended by, a spathe; perianth wanting or of 4—6 scales; seeds usually with the embryo embedded in the axis of mealy or fleshy endosperm.

The peculiar thickened fleshy flowering spadix densely covered with flowers, together with the spathe, gives this group a character of habit which is generally very distinct. The Pistiaceæ are closely related to these plants, and are regarded as the simplest form of Aroids. *Typhonium orixense* (Ghet-kachú) is very common everywhere in Bengal; the leaves are radicle, deeply 3-lobed; the flowers appear at the beginning of the rains; the spathe is shorter than the petioles, striated and erect, the inside red, the outside green. *Amorphophallus campanulatus* (Ol) is a plant with large segmented leaves; the flowers appear in June; the corms, which are dug up after the leaves have withered, are largely used as an article of food. *Colocasia antiquorum* (Kachú) is an extensively cultivated perennial herb, with large radicle peltate-sagittate leaves; the flowers are monœcious, enclosed in a yellow spathe. The lower portion of the spadix is covered with female flowers; above the female flowers are some abortive pistils, then a number of closely packed male flowers, each reduced to a single 2-celled anther opening by minute pores at the apex. The spadix is prolonged above the staminate flowers into a sterile mass of tissue. There are several varieties of this species.

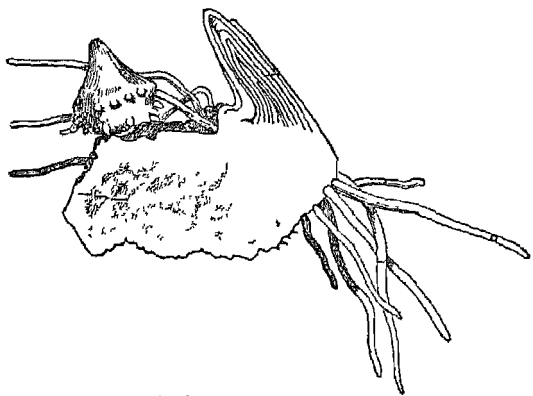
Fig. 200.



Inflorescence of an *Aroid* surrounded by a spathe.

C. indica (Mán-kachú) is much cultivated in Bengal for its esculent stems and corms; it flowers at the close of the rains and beginning of the cold season.

Fig. 201.



Section of a corm of *Arum*.

Pothos scandens, an epiphyte, is a native of Chittagong; the leaves are alternate, petioled, lanceolate, entire, smooth; the flowers are hermaphrodite.

Acorus calamus, a plant common in moist sites throughout Asia, Europe, and North America. The rhizome has long been held in esteem as a tonic, &c. *Richardia orthiopica* (Lily of the Nile) is cultivated in Himalayan stations. The plants of this order are most abundant in the tropics; the juices are generally acrid and dangerous, but heat dissipates the noxious principles.

Other genera are: *Cryptocoryne, Alocasia, Caladium, Aglaonama, Scindapsus, Arum*, &c.

Typhaceæ

Are marsh herbs, with linear leaves and monœcious flowers, arranged in spikes or heads; perianth none, or reduced to scales or bristles; ovary solitary, 1-celled; seeds with the embryo embedded in the axis of the mealy endosperm. The habit and general appearance of these plants resemble those of Cyperaceæ.

Typha elephantina (Hoglá) is a perennial herb, growing on the borders of tanks and marshy places, which do

not dry up during the hot season; the culms are from 6 to 12 feet high; the leaves are long, ensiform, and smooth; and are sometimes used for making mats. The abundant pollen is nutritious, and is made into a kind of bread in Western India, New Zealand, and elsewhere.

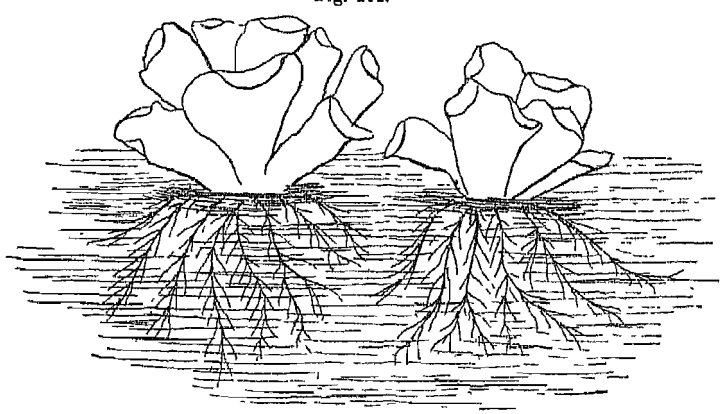
T. angustifolia (Rám hoglá) is smaller than the last mentioned species, but is found in similar places.

Pistiaceæ

Are plants floating free on water with monœcious flowers, surrounded by a spathe; each spathe containing one female flower and two or more male flowers; stamens definite, sometimes monadelphous; ovary 1-celled; embryo straight, in the axis of fleshy endosperm.

These plants are sometimes regarded as the simplest forms of the Aroids. *Pistia stratiotes* (Tákápáná) (see Fig. 203) is found floating on pools of stagnant water in most parts of India; flowering time the hot season. The flowers are monœcious, and are very beautiful when examined with an one-inch object glass.

Fig. 202.

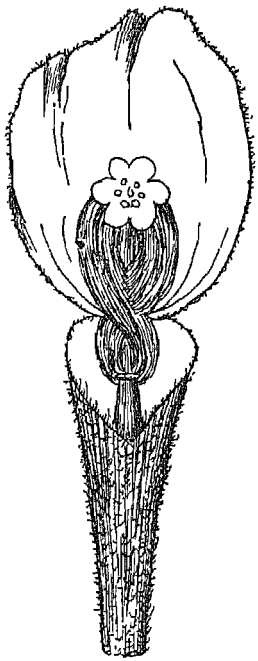


Plants of *Pistia*; the smaller one to the right is of later growth, and is connected with the parent plant by a runner.

In *Lemna orbiculata* (see Fig. 204) the leaves are minute, subsessile, orbicular, flat on both sides, from 2 to 3 together. *Wolffia Delilii* is very minute and rootless; the

leaves are globose, one or two together; and occurs with *L. orbiculata* in every tank and pool of stagnant water in Bengal, forming a green scum over the surface.

Fig. 203.



Inflorescence of *Pistia stratiotes* (magnified).

Fig. 204.

Aquatic roots of *Lemna*.

L. cruciata is generally found under the surface of the water in tanks; the leaves are petioled, lanceolate. Pistia is very widely dispersed in warm countries, whereas Lemna is equally common in hot and cold countries. These plants are useful in tending to purify the stagnant pools and ditches in which they abound. The genus Lemna is one of the simplest representatives of the Phanerogamia.

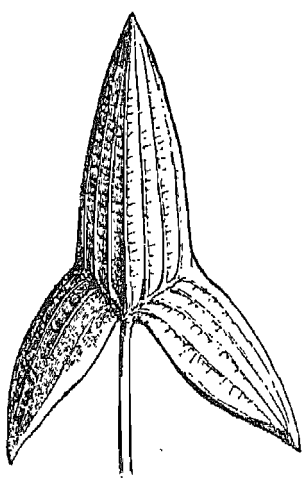
Naiadaceæ

Are floating or submerged branching plants growing in fresh or salt water; flowers inconspicuous, hermaphrodite,

monœcious, or dicœcious; perianth of 1—4 scaly pieces or none; stamens definite; pistil free, of one or more carpels; ovary 1-celled; ovule solitary; seeds without endosperm.

This order agrees with Hydrocharidaceæ and Alismaceæ in the structure of the seeds, but differs in wanting a conspicuous perianth, and in the form of the inflorescence; the structure of these plants is generally very simple. *Potamogeton indicum* is an aquatic herb, with floating, oblong or elliptical glabrous, many nerved leaves; a native of the borders of fresh water lakes and ditches; flowering time February and March. The flowers are small, numerous, of a green colour, and are borne in dense-spikes. *Spathium chinense* (Ghechú) is a native of shallow standing water, and appears and flowers during the rains. The flowers are small, purplish white, with blue anthers. The structure of these plants is generally very simple, consisting chiefly of tissue of very delicate organization. The genus *Zostera* is met with in the sea in all parts of the world.

Fig. 205.



Sagittate leaf of *Sagittaria sagittifolia.*

Alismaceæ

Are aquatic plants, mostly with broad, petiolate leaves and scapose inflorescence; flowers in racemes, umbels or panicles, perfect or monœcious; perianth of six pieces—outer three herbaceous, inner three petaloid; ovaries several, more or less distinct; seeds without endosperm.

Some of these plants bear considerable resemblance to the dicotyledonous order Ranunculaceæ. They can be distinguished from the Commelinaceæ, to which they have some similarity, by their tufter radical leaves, scapose inflorescence, apocarpous fruit, &c.

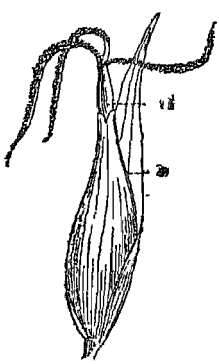
Sagittaria sagittifolia (Chota-kat) is a polygamous plant growing in marshy places, where it flowers in February, March, and April. The leaves are sagittate (see Fig. 205), the scape simple, and the flowers pure white, with a purplish base. *S. obtusifolia* (Bara-kat) is a common annual growing in swampy places, with radicle, erect, sagittate obtuse leaves; it flowers during the cold season. The scapes are from 2 to 4 feet high; flowers numerous, small, white; the lower flowers of the inflorescence are usually female.

Other genera are: *Alisma*, *Butomus*, and *Limnocharis*.

Cyperaceæ

Are grass-like herbs, with fibrous roots and solid, frequently angular stems; leaf-sheaths, closed without a ligule at the apex; flowers perfect or unisexual, each with a solitary bract or glume; perianth none or existing in the female flowers, in the form of a membranous covering, called perigynium (see Fig. 206); stamens mostly 3; ovary superior, 1-celled; seed with a lenticular embryo enclosed in the base of the endosperm. The solid, usually angular, stems, the closed leaf-sheaths, and the reduction of the floral envelopes to a single bract or glume, distinguishes these plants from the Gramineæ, which they resemble in many respects.

Fig. 206.



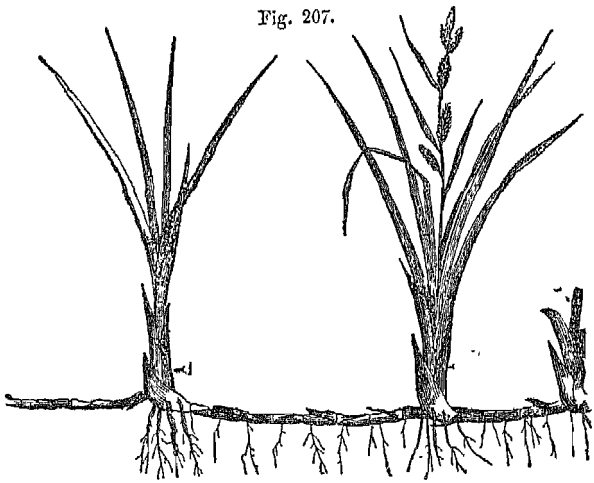
Female flower of a sedge.

Cyperus rotundus (Múlha) is by far the most common species in India; it grows abundantly everywhere; culms erect, from 1—2 feet high, three sided, smooth; umbels terminal, surrounded by a 3-leaved involucre.

Cyperus inundatus (Pátí) is found in great abundance on the low banks of rivers; it thrives most luxuriantly where the tide rises over it.

Papyrus pangorei (Mádúr kátí) is common in ditches and on the borders of marshy places during the rains:

Fig. 207.



Creeping stem of *Carex*.

what is known as "Calcutta matting" is made from the culms of this plant.

Papyrus antiquorum is a tall sedge, celebrated as having furnished the ancients with a kind of paper made from the pith.

Other genera are: *Carex, Selena, Scirpus, Mariscus: Kyllinga, Courtoisia, Fimbristylis, Isolepis, Fimrena, Rhynchospora.*

Gramineæ

Are mostly herbaceous plants, rarely arborescent, usually with hollow jointed stems, narrow alternate leaves, with sheaths split down at the side, opposite to the blade, often with a ligule at its summit; flowers usually hermaphrodite, sometimes monœcious or polygamous, either solitary or arranged in spikelets; spikelets one to many flowered, consisting of a number of bracts and the essential organs of reproduction without any perianth, or the latter represented by one or more, usually very minute, organs called lodicules. Each spikelet commonly has two or more outer or empty bracts (glumes), one (flowering glume) below each flower, and a pale enclosing each flower. The pale

differs from glumes in having no central nerve; and it usually has two lateral ones. Stamens usually 3 (in Rice and Bamboo there are 6); ovary superior, 1-celled; embryo lying at one side at the base of the farinaceous endosperm.

Fig. 208.

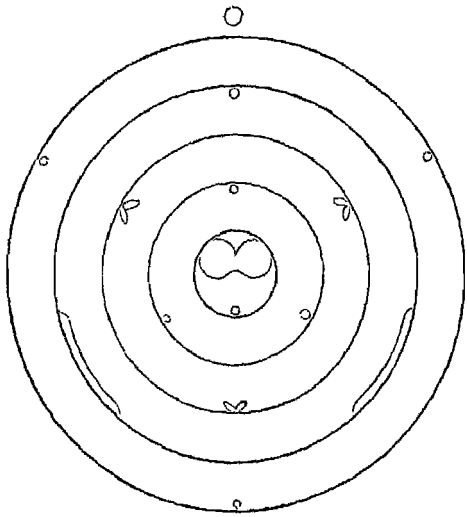
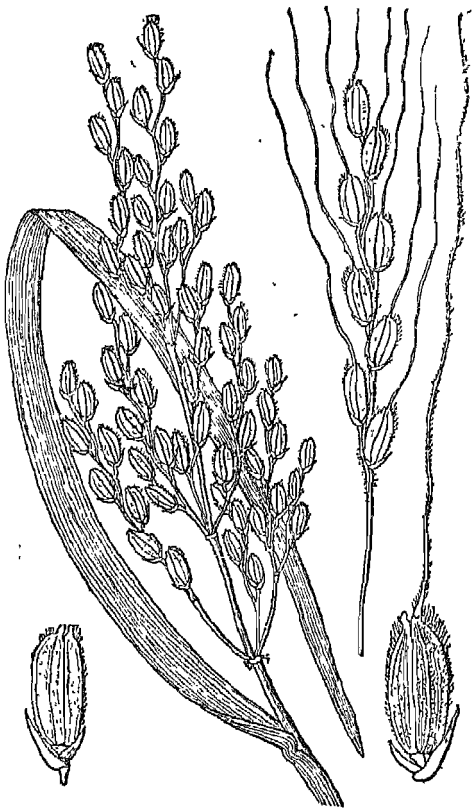


Diagram of the flower of a grass.

The flowers of most grasses may be deduced as is shown in Fig. 208 on the theory of the abortion of certain parts from the typical Monocotyledonous flower represented in Fig. 171, which is itself the typical diagram of *Liliaceæ*. The posterior leaf of the inner perianth whorl, the outer perianth whorl, the whole of the inner whorl of stamens, and the anterior carpel are wanting.

The hollow jointed stems, the leaf-sheaths split down at the side opposite to the blade, and the ligule at the base of the blade, &c., distinguish this order from the Cyperaceæ. *Sugar canes* (Uk), however, have solid stems, and the rhizomes of ordinary grasses are also commonly solid. The remarkable awn which is produced in the flowering glumes of many grasses is usually regarded as a barren development of the axis of the spikelet, which would make the inner palea the subtending bract of the flower; the ligule is generally regarded as an excrescence from the upper parts of the sheathing petiole. The main value of this order

Fig. 209.



Fruit of Rice, showing the glumes some with and some without awns.

is in the seeds or more properly the fruits, especially of what are called the cereal grains, such as Rice, Maize, Wheat, Rye, Barley, and Oats.

Mr. Bentham has lately proposed a new or modified classification of grasses, of which the following is an outline:—

SERIES A.—*Panicaceæ.*

Spikelet jointed to the pedicel below the outer glumes, with one fertile flower, with or without a male or barren flower below it.

Tribe 1, *Paniceæ*.—Spikelets hermaphrodite, rarely unisexual by abortion, spicate or paniculate; rachis of the inflorescence not jointed; flowering glume not awned, hardened in fruit or at least stiffer than the outer ones.

One of the largest tribes, particularly numerous in tropical countries. Example: Paspalum, Panicum, Pannisetum, Oplismenus, Setaria, etc.

Panicum commutatum (Mákar-jálí) is a common grass of which cattle are very fond.

Tribe 2, *Maydeæ*.—Spikelets unisexual; the male terminal, spicate or paniculate, the females spicate at the base of the males or in a separate inflorescence, disjoining from the rachis, except in Zea.

A very small tribe, including the genera Coix and Zea.

Zea mays (Bhúta), the largest cereal; it is cultivated in various parts of India; the flowers are monœcious—a rare occurrence among the Gramineæ.

Tribe 3, *Oryzeæ*.—Spikelets hermaphrodite or rarely unisexual, paniculate or spicate; rachis of the inflorescence not jointed; scale or glume next the flower 1-nerved or keeled, not 2-nerved as in most grasses.

Also a small tribe, yet it includes the important genus Oryza.

Oriza sativa (Dhán): the flowers of this well-known useful cereal have 6 stamens.

Tribe 4, *Tristegineæ*.—Spikelets hermaphrodite, solitary geminate or fasciculate along the branchlets of the inflorescence; empty glumes awned or awnless; flowering glume transparent or membranous, awnless or terminating in an awn.

An unimportant tribe, scarcely represented in India except by the monotypic Thysanolæna.

Tribe 5, *Zoysieæ*. — Spikelets hermaphrodite or some of them imperfect, not jointed to the rachis, solitary or clustered; flowering glume membranous, often smaller than the empty ones and transparent.

Zoysia procumbens and Lappago procumbens are common representatives of this small tribe.

Tribe 6, *Andropogoneæ*.—Spikelets in pairs at each node of the jointed rachis of the spike or of the branches of the panicle, or in triplets at the end of each branch; the

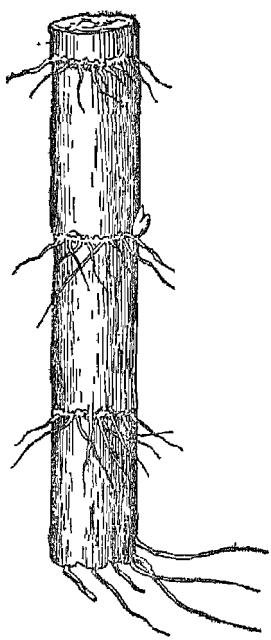
spikelets of each pair or triplet homogamous or heterogamous; flowering glume smaller than the empty ones by a line, and often awned.

A large tribe, chiefly tropical and subtropical. Among other genera it includes Saccharum, Erianthus, Hemarthira, Ischæmum, Sorghum, Chrysopogon.

S. cylindricum (Ulú) is a native of moist stiff pasture ground, particularly common over Bengal, where the fields are white with it when in flower after the first rains in April and May; it is generally used for thatching.

The fragrant roots of *Andropogon muricatus* (Khaskhas) are well known all over India; they are used for making tatties, covers for palkis, &c. It usually grows in low, moist, rich soil, on the banks of rivers.

Fig. 210.



Cutting of a Sugar-cane showing secondary roots developed from the nodes.

Saccharum officinarum (Uk) has solid culms from 6—12 feet high; extensively cultivated for its sugar-producing qualities; it flowers during the rains. *S. spontaneum* (*Kash, kese*) has culms from 5—15 feet high; it grows on the banks of rivers, railways, and other uncultivated land; it is used for making mats and for thatching houses.

SERIES B.—*Poaceæ.*

Pedicel continuous below the outer glumes; rachis often jointed above the persistent outer glumes, produced above the fertile flower, stalk-like or bearing empty glumes or imperfect flowers, or sometimes with one terminal flower as in the Paniceæ, but then falling away with its glume from the persistent empty glumes.

Tribe 7, *Phalarideæ.*—Hermaphrodite flower 1; terminal glumes 6 (or 5 and a pale), 1-nerved or keeled.

A very small tribe, represented in the hills of Northern India by three or four species of Hierochloë and Phalaris.

Tribe 8, *Agrosteæ*. — Spikelets 1-flowered; rachis produced or not beyond the flower in the form of a bristle.

This tribe is a rather large one, and is again divided into four subtribes. The species are mostly temperate and subtropical. Sporobolus is an Indian genus.

Tribe 9, *Isachneæ*. — Spikelets equally 2-flowered; glumes usually awnless; rachis not produced beyond the flowers. Example: Isachne.

Tribe 10, *Aveneæ*.—Spikelets two or more flowered, often panicled; flowering glumes almost always furnished with a dorsal, rarely terminal awn; rachis usually produced beyond the flowers.

Mostly grasses of temperate climates. Species of the typical genus, Avena, yield the valuable northern cereal oats.

Tribe 11, *Chlorideæ*.—Spikelets one or more flowered; sessile in two rows along the rachis of the unilateral spikes. Elensine and Chloris are representative genera.

Tribe 12, *Festuceæ*.—Spikelets two or more flowered, variously paniculate or rarely racemose; flowering glumes awned or awnless.

This tribe is numerous in genera and species; but they are chiefly inhabitants of temperate regions. Exagrostis is a large genus represented in tropical India.

Tribe 13, *Hordeæ*.—Spikelets one or more flowered; sessile in notches of the rachis of the simple spikes.

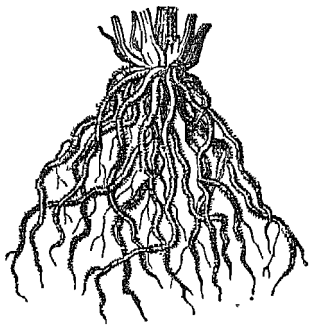
This tribe is neither numerous in genera nor species, yet it is one of the most important, as it embraces several of the most widely cultivated cereals, as Wheat (Triticum), Barley (Hordeum), and Rye (Secale).

Tribe 14, *Bambuseæ*.—Tall grasses, often woody, at least at the base; leaves flat; limb very often jointed to the sheath; spikelets one or more flowered; stamens 3—4 or more.

The bamboos are one of the most useful and important tribe of tropical and subtropical grasses.

The Gramineæ constitutes one of the largest natural orders, and includes probably from 3,000 to 4,000 species. They are universally distributed and have been culti-

Fig. 211.



Secondary roots as in most grasses.

Fig. 212.

Imbricated æstivation of a grass (see page 17).

vated from the remotest antiquity. Rice furnishes a larger proportion of food than any other single species.

Rye, barley, and oats are the hardier "cereal grains;" wheat is the chief grain of temperate and warm temperate climates. Rice and maize form the chief grains of the tropics: maize or Indian-corn, the largest cereal, is a plant of American origin.

The first division, the Zygomycetes (or Zygospermeæ Achlorophyllaceæ), is composed of the Mucorini only (including the Piptocephalidæ). The second, the Oomycetes (or Oospermeæ Achlorophyllaceæ), comprises the Peronosporeæ and Saprolegnieæ (including the Chytridiaceæ). The third, the Carpomycetes (or Carpospermeæ Achlorophyllaceæ), is made up of the Uredineæ, Ustilagineæ Basidiomycetes, and Ascomycetes, the lichenes being included in the last as a sub-order.

"The Algæ are arranged under three corresponding subclasses. The Zygophyceæ (or Zygospermeæ Chlorophyllaceæ) is made up of the following orders:—Pandorineæ, Hydrodictyeæ, Confervaceæ (under which the Pithophoraceæ may possibly come), Ulotrichaceæ, Ulvaceæ, Botrydieæ, and Conjugatæ (the last comprising the Desmidieæ, Diatomaceæ, Zygnemaceæ, and Mesocarpeæ). The Oophyceæ (or Ospermeæ Chlorophyllaceæ) includes the Volvocineæ, Siphoneæ (with the nearly allied Dasycladeæ), Sphæropleaceæ (Œdogoniaceæ), Fucaceæ, and Phæosporeæ. The Carpophyceæ (or Carpospermeæ Chlorophyllaceæ) is made up of the Coleochæteæ and Florideæ.

"The Characeæ constitute by themselves a group of primary importance; the Muscineæ are unchanged, comprising the Hepaticæ and Musci (including Sphagnaceæ).

"In vascular Cryptogam it is proposed to revert to the primary distinction into Isosporia and Heterosporia as most in accordance with probable genetic affinities. The Isosporia consist of the Filices (including Ophioglossaceæ), Lycopodiaceæ, and Equisetaceæ. The Heterosporia comprise the Rhizocarpeæ and Selaginellaceæ. In the terminology of the Heterosporia, the inconvenience and incorrectness are pointed out of the use of the terms 'Macrospore' and 'Macrosporangium;' and it is proposed to call the two kinds of spores, and their receptacles respectively, Microspore, Megaspore, Microsporangium, and Megasporangium; or better, in reference to their sexual differentiation, Androspore, Gynospore, Androsporangium, and Gynosporangium."

W. H. G.

CHINSURAH;
November, 1882.

GYMNOSPERMIA.

The second group of flowering plants (the gymnospermia) produce ovules on open carpellary leaves; the endosperm arises *before* fertilization, and *the contents of the pollen-grains are divided before the formation of the pollen tube.* In the peculiarities of their tissues and especially of their sexual reproduction, these plants occupy an intermediate position between Angiosperms and vascular Cryptogams. In the anatomical structure of the wood, Gymnosperms resemble Dicotyledons. They differ, however, in the layers of wood which are formed after the first year, being destitute of vessels and ducts and in the usual presence of bordered pits in the wood-tissue.

The Gymnosperms are divided into three orders, embracing plants of strikingly different habit, but closely allied in their morphological structure :—

Order I.—*Gnetaceæ*

Are shrubs or rarely small trees, usually with jointed stems, and destitute of the resin so characteristic of conifers. There are only three genera belonging to this order. *Ephedra,* which approach the Casuarina in habit, are confined to the Himalayas and other temperate regions. The species of *Gnetum* are climbling shrubs, with opposite glabrous leaves and monœcious flowers; the male flowers each consist of a single stamen, with a 2-celled anther or of 2 stamens having 1-celled anthers, the female of a naked ovule enclosed in an undivided perianth.

Welwitschia mirabilis, the only representative of the third genus, is a native of the desert regions of South-Western Africa; it is a most extraordinary dwarf-tree, seldom rising more than two feet above the sand in which it grows; it never has more than two leaves, but these are of immense size, and were believed to be the cotyledons; but it has

lately been ascertained that the cotyledons perish early and are succeeded by one pair of permanent leaves; the plant attains an age of at least a hundred years.

Order II.—*Coniferæ*

Are trees or shrubs, with small, usually needle-shaped or scale-like leaves, rarely flat, as in Podocarpus. The flowers are always incomplete, and either monœcious or dicœcious; the female flowers are of various forms, and are either solitary or united into cone-like inflorescences. The male flowers consist of a slender short or elongated axis on which the numerous staminal leaves are arranged.

The affinity of the Coniferæ are with Dicotyledons by their habit of growth, although there is an essential difference in the internal structure of their organs. The pitted woody tissue with the absence of vessels and ducts serves to distinguish the wood of coniferous stems. The Coniferæ may be roughly divided into three tribes—namely, the Abietineæ, the Cupressineæ, and the Taxineæ:

Tribe 1. *Abietineæ.*—Flowers usually monœcious; cones usually large, the scales becoming more or less woody; ovules two or more at the base of each scale, inverted. Trees with long needle-shaped leaves in fascicles of two, three or five according to the species (Pinus longifolia), or linear scattered leaves (Cedrus deodara), or small or large scale-like leaves (Araucaria sequoia).

Pinus longifolia is common in the Himalayas at elevations of 5,000 to 6,000 feet. The wood is light, and being full of resinous matter is frequently employed in the hills for making torches.

P. deodara (Debpárú) is also a Himalayan tree; the wood is durable and is used in the construction of Himalayan houses. Both these trees yield a large quantity of turpentine and resin.

Tribe 2. *Cupressineæ.*—Female flowers in small cones or strobiles consisting of a few scales and no bracts, usually thickening and forming a globular or ovoid fruit; ovules and seeds erect, one or more at the base of each scale. Trees or shrubs with small spreading awl-shaped, or scale-like closely imbricated leaves. Examples: Juniperus communis, Thuja orientalis.

Tribe 3. *Taxineæ.*—Fertile flowers, solitary, ripening into a fleshy fruit; ovule erect; leaves linear, scattered (Taxus); leaves flat, rather broad (Podocarpus). In this genus, the last trace of resemblance in habit to the flowers of Angiosperms ceases, only a few ovules being produced on a naked inflorescence; the flowering shoots are developed from the axils of foliage leaves.

In Hooker and Bentham's *Genera Plantarum* the order is divided into six tribes, based upon modifications of the inflorescence and the position of the ovules.

ORDER III.—*Cycadeæ*

Are tropical or subtropical dicecious trees or shrubs, with simple or branched stems, resembling palms and tree ferns in their habit; the flowers are arranged in terminal cones at the apex of the stem in the centre of the crown of leaves, or they are lateral.

In *Cycas* the female cone is truly terminal, consisting of a rosette of scales or leaves similar to the ordinary ones, though smaller and ovuliferous only in their lower parts, and further growth takes place through its axis. There is, in fact, an alternation of ordinary leaves and ovuliferous leaves on the same axis. In all the other genera, the cones are subterminal and deciduous. The ovules are borne on flat or peltate scales, either beneath, or at the base, or on the margins. The *ovule* contains several embryos, but only one is developed; the seeds have a hard or succulent testa. The 1-celled anthers or polliniferous cells cover the under surface of the male cone-scales. The distribution of the reproductive organs over the leaflike carpels together with the occasional circinate vernation of the leaf-segments connect this order with the ferns.

Fig. 213.

Cycas revoluta (after *Oliver*).

Cycas revoluta is very common in gardens about

Calcutta. It has somewhat the appearance of a tree fern; it lives to a considerable age. *C. circinalis* is common in gardens near the sea-coast of the southern provinces of Malabar; a kind of flour is prepared from the fruit after it has been dried some time. *C. rumphii* is a peculiar branched species; it is occasionally cultivated in gardens. There are some fine specimens of this plant in the Botanical Gardens, Shibpur. The stem is marked with scars of two kinds—those of the true leaves and those of the floral leaves.

Zamia longifolia and *Z. horrida* are also sometimes cultivated.

CRYPTOGAMIA.

The second division of the vegetable kingdom—Cryptogamia (see abstract, page 80*g*)—includes plants destitute of flowers, containing anthers and ovules. In Phanerogams, two sexual cells, dissimilar in form, size, and other respects, perform the process of fertilization; one of the two sexual cells is the *male, sperm,* or *pollen-cell,* the other the *female, germ-cell,* or *germinal vesicle.* From the connection of these dissimilar cells, a structure arises which can no longer be considered a part of the connected conformation of the parent plant. These plant structures form a *generation.*

In most Thallophytes, and in all Muscineæ and vascular Cryptogams, the generations which proceed from one another are dissimilar, having dissimilar habits of life and conformation. For example, a generation of the kind *A* will produce one of the kind *B*, and this again one of the kind *A*. "The whole process of development which passes through the successive dissimilar generations, and finally returns again to the first form, is called *alternation of generations.*" (A more comprehensive conception of the alteration of generation makes it applicable to flowering plants; but in these the first generation does not exist as an independent growing plant. The endosperm of flowering plants has been regarded as analogous to the prothallium, the embryo-sac to the macrospore, and the pollen-grain to the microspore of certain Cryptogams. But the endosperm is often wanting, and alternation of generation has almost disappeared.)

"It is only in some Algæ and Fungi that all successive generations are similar and produce similar reproductive

cells," as in Nostocaceæ, etc., where asexual generations follow one another without intermission. In Spirogyra, etc., an uninterrupted series of sexual generations succeed one another.

The usual case among Algæ and Fungi, and the universal one among Muscineæ (Mosses and Liverworts) and vascular Cryptogams (Ferns, Horse-tails, and Stag-mosses), is, however, for sexual and asexual generations to alternate regularly. When the reproductive cells are asexual, that is, developed independently of any foreign aid, the generation from which they are derived is called an *asexual generation*. The asexual reproductive cells usually become detached from the mother plant, and are dispersed (hence called *spores*), in order to produce the new generation at a distance from it. When the reproductive cells are sexually developed, the generation to which they owe their origin is called a *sexual generation*. One of the two sexual cells, the germ or female cell, generally continues to lie in a special organ of the mother plant (the *oogonium, archegonium*), and there waits fertilization by the other sexual or male cell (*spermatozoid, antherozoid*).

The classification of Cryptogams proposed in the fourth edition of Sachs' Lehrbuch der Botanik is here adopted; it rests on such a sound scientific foundation that it must ultimately come into general use in its main features. The whole range of Cryptogams he divides into three groups: *1st*, Vascular Cryptogams; *2nd*, Muscineæ; and *3rd*, Thallophytes.

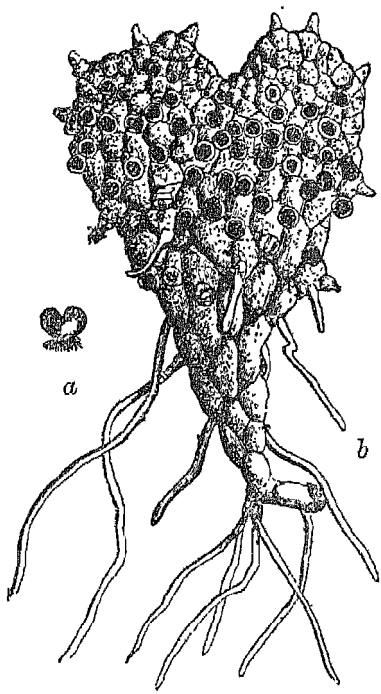
GROUP I.—VASCULAR CRYPTOGAMS.

In vascular Cryptogams, the *sexual generation* which proceeds from the spores is a small body of the simplest kind, without any considerable differentiation of tissues. It appears externally as a mere precursor of further development; hence the name *prothallium* (see Fig. 166) has been given to it. In Filicineæ and Equisetaceæ, the prothallium carries on an independent existence resembling the thallus of the lower Hepaticæ (liverworts). In the Dichotomeæ (Selaginella, Club-mosses) it becomes simpler, and its morphological differentiation less pronounced. In Ferns and Equisetaceæ, the prothallia continue to grow

for a considerable time, and contain a large amount of chlorophyll and form numerous root-hairs.

When mature, the prothallia produce the *archegonia* (a special organ of the mother plant, in which the germ-cells are formed), and *antheridia* (cells, or masses of cells, which produce the male reproductive bodies), usually in considerable numbers; in Equisetaceæ these prothallia are usually dicœcious, the male prothallia being smaller than the female; in ferns, monœcious, although they both proceed from similar spores.

Fig. 214.



Prothallium (sexual generation) of a fern.
a. The prothallium, natural size, to be found on damp walls, etc.
b. The same prothallium magnified.

In the division Rhizocarpeæ and Ligulatæ, there are two kinds of spores—*macrospores* (female) and *microspores* (male). The macrospores develop a female prothallium, which remains within the spore, or is only partially protruded, and which produce exclusively archegonia, or sometimes only a single one. In Ligulatæ, the prothallium is developed in the spore itself, filling it up with a mass of tissue, the archegonia becoming exposed only by the splitting of the cell-wall of the spore. This process is similar to what takes place in the ovules of gymnosperms, where, before the pollen-grains fall on the micropyle, the embryo-sac becomes filled up by free cell formation with

delicate cellular tissue (the endosperm), in which are formed the *corpuscula* or secondary embryo-sacs, and which are very much like the archegonia in the internal prothallium structure of Selaginella. The microspores produce a rudimentary male prothallium, which remains within or attached to the spore, analogous to what is seen in the pollen-grains of Gymnospermia, which, in like manner, produce a rudimentary prothallus.

The *archegonia* of vascular Cryptogams are like those of the Muscineæ, consisting of a cup-shaped mass of tissue enclosing the *oosphere* (female-cell) and of a restricted portion, the neck. The flask-shaped archegonia are hollow receptacles formed in the thick part of the prothallium, and have a narrow neck-like passage through which the antherozoids reach the oosphere (female-cell). In vascular Cryptogams, however, the tissue of the ventral part is formed from the prothallium itself. The antherozoids or spermatozoids, as they are sometimes called, are similar to those of the Muscineæ spirally coiled threads, usually with a number of fine cilia on the anterior coils. *The asexual generation is that in which the plants are commonly seen and known,* and during which they attain the highest degree of development; in the vegetative structure, they arise from the oospore (fertilized oosphere) in the archegonium; they soon become independent plants, which free themselves at a very early period from the prothallium, and obtain their own nourishment. *It is this asexual generation which is called in ordinary language the Fern, Equisetum,* etc. Roots are usually present except in Salvinia, Psilotum, and some species of Hymenophyllum, and they always remain nearly uniform in size. The leaves are not so varied in their forms as in Phanerogams; they are either simple, segmented or variously branched. The differentiation of the tissues into epidermis, fundamental tissues, and fibro-vascular bundles are always clearly distinguishable. Vascular Cryptogams form a group connected with one another by very obvious bonds of relationship, but may be divided into three tolerably well marked classes: (1) *Filicineæ;* (2) *Equisetaceæ;* and (3) *Dichotomi:*

Abstract of Vascular Cryptogamic Orders.

VASCULAR CRYPTOGAMS.

- Filicineæ ...
  - Stipulatæ ...
    - Ophioglossaceæ. Ex.: Adder's Tongue.
    - Marattiaceæ. Ex.: Marattia.
  - Filices ...
    - Polypodiaceæ. Ex.: Maiden-hair, etc.
    - Cyatheaceæ. Ex.: Tree Ferns.
    - Osmundaceæ. Ex.: Royal Fern.
    - Schizæaceæ. Ex.: Twining Fern. Lygodium.
    - Gleicheniaceæ. Ex.: Gleichenia.
    - Hymenophyllaceæ. Ex.: Film Ferns.
  - Rhizocarpeæ ...
    - Marsileaceæ. Ex.: Pepper-worts.
    - Salvineaceæ. Ex.: Water Ferns.
- Equisetaceæ ... Equisetaceæ. Ex.: Horse-tails.
- Dichotomi ...
  - Ligulatæ ...
    - *Selaginelleæ. Ex.: Selaginella.*
    - Isoeteæ. Ex.: Quill-wort.
  - Lycopodiaceæ ...
    - Lycopodieæ. Ex.: Stag's horn Moss.
    - Psiloteæ. Ex.: Psilotum.

Class I.—Filicineæ.

The second or asexual generation are plants with large usually divided leaves, bearing *sporangia* (capsules containing spores) (see Fig. 167), collected in *sori* (groups of sporangia), usually on the under surface of the leaf. The Filicineæ are divided into—(1) *Stipulatæ;* (2) *Filices;* (3) *Rhizocarpeæ.*

Fig. 215.

A sporangium of a Fern (magnified).

Division I.—Stipulatæ.

These plants, hitherto included among ferns, must be separated from them in consequence of the entirely different mode in which their sporangia are formed; they agree with the sporangia of all vascular Cryptogams, in the one point of belonging to the leaves. The sporangia in the Stipulatæ are not, however, products of single epidermal cells, as in Ferns and Rhizocarps, but their origin more resembles that of the pollen-sac of the anthers of many angiosperms. The stipulate structure occurring in these plants is entirely foreign to ferns. The second or asexual generation is usually unbranched, the leaves stipulate, and the sporangia are produced from the mesophyll of the leaf, and of one kind only. The Stipulatæ are divided into two orders—*Ophioglossaceæ* and *Marattiaceæ*.

Order 1.—*Ophioglossaceæ*.

The prothallium is developed underground and is destitute of chlorophyll. The leaves are not circinnate in vernation; and the sporangia dehisce by two valves opening down the side nearly to the base; they have no ring or annulus.

Order 2.—*Marattiaceæ*.

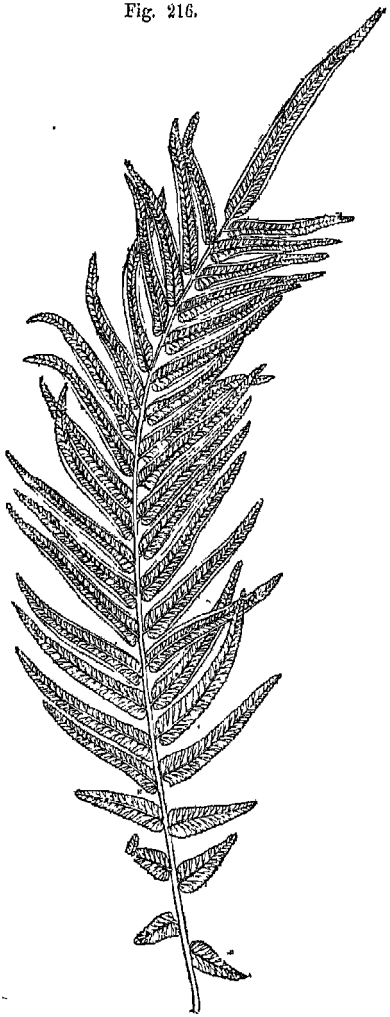
The leaves are circinnate in vernation; the sporangia open by pores or by a slit down one side of the capsule; they are without a ring, and are usually jointed together in concrete masses (synangia).

Division II.—Filices.

The sexual generation or prothallium arising from the spores of the plants of this group, is a thalloid structure containing chlorophyll, and obtaining its nourishment independently; it produces simple root-hairs (rhizoids), and finally antheridia and archegonia; the prothallia of Polypodiaceæ are bright green organisms of a scale-like appearance; they grow abundantly on old walls and low ground, in damp and shady situations; they are found most abun-

dantly at the beginning of the rainy season. The prothallia are monœcious, though, as in Osmunda, they show a tendency to be dicœcious.

Fig. 216.



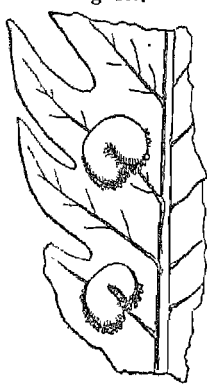
Pinnate leaf (frond) of a Fern.

The second or asexual generation or fern as it is popularly termed, is erect and unbranched, or prostrate and slightly branched; the mature fern is in some Hymenophyllaceæ, a small delicate plant, not much exceeding in dimensions the larger Muscineæ; in other sections, the fully grown plants attain the size of considerable shrubs; some species assume even a palm-like habit, and are called tree ferns.

The leaves (commonly known as *fronds*) are not stipulate, they are usually characterized by a circinnate vernation, and they only unroll in the last stage of their growth. The form of the leaves are among the most perfect in the whole vegetable kingdom, the laminæ are usually deeply lobed, branched, or pinnate. In Lygodium the leaf-stalk or rachis resembles a twining stem, growing for a long period, the pinnæ presenting the appearance of leaves.

The *sporangia* (*capsules*) *arise from single epidermal* cells, and are usually stalked unilocular capsules. A ring of cells is generally developed on the capsule in a peculiar manner, and is termed the *annulus* (see Fig. 167); by its contraction when it dries up, the capsule bursts. Sometimes, instead of the annulus, a terminal or lateral group of cells of the wall of the capsule is developed in a similar manner. The sporangia are generally combined into groups (sori), each group being termed a *sorus* (see Fig. 217). The sorus contains either a small definite number, or a large indefinite number, of sporangia. The whole sorus is generally covered by an outgrowth of the epidermis, the *indusium* or involucre (see Fig. 217). In some cases the sori are uniformly distributed over the whole of the lamina: in others they are connected with definite portions of it. The spores are of one kind only; they do not usually germinate till a considerable time after dissemination.

Fig. 217.



Portion of a frond with two sori covered by indusia.

The systematic *classification* of ferns is based artificially on the form of the mature sporangia for the orders, and of the form and arrangement of the sori for the genera. The Filices may be divided into six orders: (1) *Polypodiaceæ*; (2) *Cyatheaceæ*; (3) *Osmundaceæ*; (4) *Schizæaceæ*; (5) *Gleicheniaceæ*; and (6) *Hymenophyllaceæ* (see Hooker and Baker's Synopsis Filicum):—

Order 1.—*Polypodiaceæ.*

Sori dorsal or marginal, of many capsules, usually pedicellate; annulus vertical and incomplete; dehiscence transverse.

Order 2.—*Cyatheaceæ.*

The annulus is complete, oblique; dehiscence transverse; sporangia sessile. Mostly tree ferns.

Order 3.—*Osmundaceæ.*

Sporangia shortly stalked; dehiscence longitudinal, 2-valved, opening across the apex, furnished with a short horizontal ring.

Order 4.—*Schizæaceæ.*

The annulus is in the form of a cap; the dehiscence is longitudinal; capsule 2-valved, opening down the side. In Lygodium, the climbing leaf-stalk ends in a lamina, which is not circinnate.

Order 5.—*Gleicheniaceæ.*

The sori are dorsal; sporangia sessile, arranged in threes, or fours, with a complete transverse annulus; dehiscence longitudinal; involucre none.

Order 6.—*Hymenophyllaceæ*

Are small, often epiphytal ferns. The sporangia are formed on a prolongation of the vein, beyond the margin of the leaf; the annulus is horizontal or oblique; dehiscence longitudinal.

Division III.—RHIZOCARPEÆ.

The sexual generation of Rhizocarpeæ is developed from spores of two different kinds,—the smaller, the microspores (male), and the larger (which exceed the smaller several hundred times in size), the macrospores (female). The sporangia are formed in hollow capsular stalked receptacles, closed on all sides, usually termed sporocarps.

The Rhizocarpeæ is divided into two orders:

Order 1.—*Marsileaceæ*

Are perennial plants, creeping in mud; microspores and macrospores in the same sporocarp. Example: *Marsilea quadrifolia.*

Order 2.—*Salviniaceæ*

Are annual plants floating on water; microspores and macrospores in distinct sporocarps. Example: Water Ferns.

Class II.—Equisetaceæ.

The second or asexual generation are herbaceous plants, with fistular jointed stems (horse-tails), see Fig. 218. In the sexual generation the prothallia are generally diœcious; the male prothallia are small, the female are much larger (as much as half an inch).

All existing forms are so nearly related to one another that they may be included in a single genus *Equisetum;* even the Equisetaceæ of earlier geological periods, the *Calamities*, show in the little that is still discernible of their organization, the closest agreement with existing forms.

Class III.—Dichotomi.

The second or asexual generation is usually repeatedly dichotomously branched, with very small 1-nerved leaves; the sporangia are solitary. The Dichotomeæ may be divided into two divisions: Ligulatæ and Lycopodiaceæ.

Division I.—Ligulatæ.

The leaves are furnished with a ligule near the base; the spores are of two kinds. The prothallia are small, and are never independent of the spores.

Order 1.—*Selaginelleæ.*

The leaves are small, scale-like, are placed in four rows, and are of different sizes; the lateral rows consisting of larger, the upper and under of smaller leaves.

Order 2.—*Isoeteæ*

Are aquatic plants, with a simple cylindrical but only slightly developed stem, with long grass-like leaves.

Division II.—Lycopodiaceæ.

The Lycopodiaceæ possess only one kind of spore; the leaves are simple sessile, and with a single central vein; they are all of the same size, and are arranged spirally on the stem.

Order 1.—*Lycopodieæ*

Are plants with procumbent stems, hard and woody. Several species of the Lycopods are commonly known as stag's horn moss, or club moss.

Order 2.—*Psilotece*

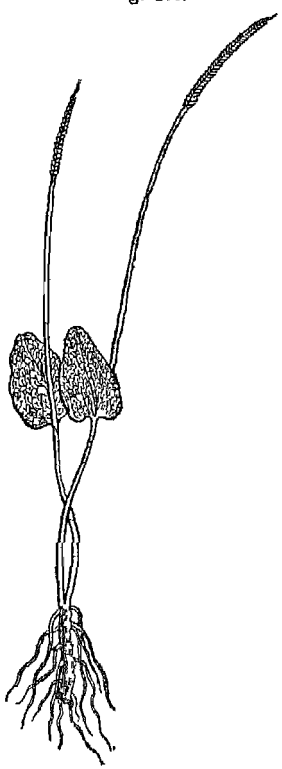
Are plants with long, slender, many forked stems, and very small rudimentary leaves; true roots are altogether wanting; the sporangia are trilocular.

Details of Vascular Cyptogamic Orders.

Order I.—Ophioglossacece.

In the sexual generation the Ophioglossaceæ is a monœcious prothallium developed underground; which produces a number of antheridia and archegonia; the antheridia are cavities in the tissue of the prothallium; the antherozoids are similar in form but larger than those of the Polypodiaceæ. The archegonia are developed in a similar manner to those of other vascular Cryptogams.

Fig. 218.



Ophioglossum.

The asexual generation bears the sporangia, which are essentially different from those of ferns; they agree with the sporangia of all vascular Cryptogams in the one point of belonging to the leaves; they are not, however, the product of single epidermal cells, as in Ferns and Rhizocarps. The sorus is an entire lobe of a leaf, the inner tissue of which produces the mother cells of the sporangia, thus resembling the pollen-sac of the anthers of many angiosperms. *Ophioglossum reticulatum* (Bak, Ekteera) is a native of cool, shady places, where it

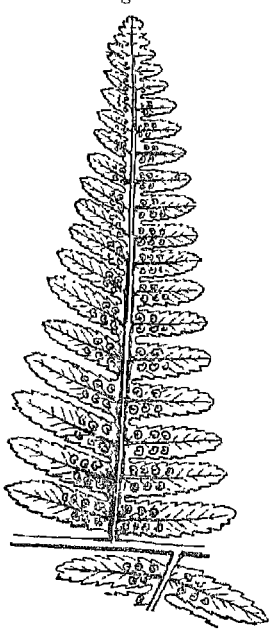
appears during the rainy season. *O. vulgatum*, L., is the common adder's tongue. Other genera are: *Botrychium*, Swartz; and *Helminthostachys*, Kaulf.

Order II.—Marattiaceæ.

In this order the sori are placed singly on lateral veins of the pinnæ, to which they are attached by a narrow ridge shaped base; they resemble the Ophioglossaceæ in the origin of their spores, and by their stipular structure which is entirely foreign to true ferns. The commonest genera are: *Marattia*, Sm. (which is a well-marked genus, extending all round the world within the tropics); and *Angiopteris*, Hoffm.

Order III.—Polypodiaceæ

Fig. 219.



A portion of the leaf (frond) of a fern showing the spore cases in which the spores are formed.

Are ferns with stalked sporangia, having a vertical incomplete annulus with transverse dehiscence. This order may be divided into ten sub-orders, which may be grouped into two divisions; the first (Involucratæ) containing plants having an indusium, the second (Exinvolucratæ) comprising those which have none (see Hooker's and Baker's Synopsis Filicum):

A.—INVOLUCRATÆ.

1. *Asplenieæ.* The sori are unilateral on the course of the veins.
2. *Aspidieæ.* Indusium uniform or peltate.
3. *Davallieæ.* The sori are terminal on a vein, or at a fork or are placed on a intra-marginal anastomosing bend of the veins.
4. *Lindseæeæ.* Indusium bursts along its outer margin, attached interiorly.
5. *Pterideæ.* Sori usually linear marginal; indusium bursting along its outward margin, attached exteriorly.
6. *Blechneæ.* Sori linear situated between the mid-rib and margins of the leaflets.
7. *Dicksonieæ.* Indusium cup-shaped, reflexed.

B.—EXINVOLUCRATÆ.

8. *Acrostichieæ.* Fronds wholly fertile.
9. *Polypodieæ.* Sori usually globose.
10. *Grammitideæ.* Sori linear or oblong.

1.—The *Asplenieæ include the genera Asplenium, L.*; Allantodia, R. Br.; and Actiniopteres, Link.

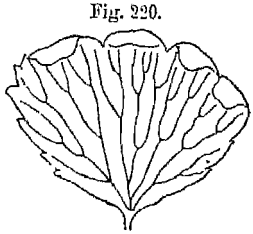
2.—*Aspidieæ* contain the genera Aspidium, a cosmopolitan genus; Nephrodium, also cosmopolitan; Nephrolepis; Oleandra, a small genus almost restricted to the tropics, distinguished from Nephrodium mainly by habit, having widely creeping scandent shoots, jointed stems, and entire lanceolate elliptical fronds.

3.—*Davallieæ* include the genera Davallia, Cystopteris, a genus allied to Woodsia.

4.—*Lindseæeæ* contain only a single genus Lindsæa.

5.—*Pterideæ* contain the genera *Adiantum* (maiden-hair ferns), most of the species of which are recognizable from all other ferns except the typical Lindsæa by the texture and one-sidedness of their segments; *Cheilanthes*, in which the fronds are under a foot long, often under six inches. It is very difficult to draw the line between Cheilanthes and Nothochlæna, which is the corresponding non-indusiate genus. *Onychium, Cryptogramme, Pellæa, Pteris*, a large cosmopolitan genus; *Ceratopteris* and *Lomaria*, a considerable genus closely connected with Blechnum.

Fig. 220.



Leaflet of an *Adiantum*.

6.—*Blechneæ* contain the genera *Blechnum, Woodwardia*, and *Doodia*.

7.—*Dicksonieæ* contain the genera *Onoclea*, large herbaceous ferns; *Woodsia*, small herbaceous much tufted ferns; *Sphæropteris*, and *Dicksonia*.

8.—*Acrostichieæ*, containing the single genus *Acrostichum*, L., are readily distinguished by the back of the fronds being almost or entirely covered with spore-cases.

9.—*Polypodieæ*, including also only one genus *Polypodium*, which contain a larger number of species than any other genus.

10.—*Grammitideæ* include the genera *Nothochlæna*, R. Br.; *Gymnogramme Desv*, *Brainea*, K., a genus of subarborescent ferns; *Meniscium*, Schreb.; *Antrophyum*, Kaulf., ferns with simple fronds of firm but fleshy texture; *Vittaria*, ferns having grass-like fronds of subcoriaceous texture; *Drymoglossum*, Prsl.; and *Hemionitis*, L.

Order IV.—Cyatheaceæ.

The Cyatheaceæ are mostly tree ferns. The sori more or less elevated on a common receptacle are dorsal, globose; sporangia sessile or stalked, with an oblique annulus; dehiscence transverse; involucre scale-like, or cup-shaped, or absent in alsophila. Common genera are: *Cyathea*, Sm.; *Alsophila*, R. Br.; *Diacalpe*, Bl.; *Matonia*, R. Br. (not arborescent); and *Hemitelia*. The Alsophila are arborescent ferns, with the general habit of Cyathea and Hemitelia, but destitute of involucre. *Alsophila latebrosa*, H. K., is common almost throughout India proper and the Malay Islands, and is the common kind of tree fern seen round Darjiling.

Order V.—Osmundaceæ.

The Osmundaceæ are striking ferns, clearly marked by habit. The numerous shortly-stalked sporangia are arranged in dense sori on the back of the frond or in a spike or panicle, due to the non-development of the parenchymatous tissue between the veins; the annulus is horizontal and incomplete; the dehiscence is longitudinal. Other genus, *Todea*, Willd.

Order VI.—Schizæaceæ.

The sporangia are ovoid or pear-shaped; sessile or shortly-stalked, opening down one side; the annulus is complete

and circular, and is in the form of a cap, on the summit; the dehiscence is longitudinal. Lygodium is a small widely diffused genus, well characterized by its scandent twining stem. The primary branches end in a lamina which is not circinnate. *Lygodium scandens*, Lin., is common in most parts of India; the sporangia appear in the rains and cold season; the compound fronds are like slender climbing stems, bearing small fronds, and are of indefinite growth. *Lygodium flexuosum*, Sw. (Bhut-raj), is a perennial scandent plant; the fronds are compoundly pinnate; the ultimate segments are long and narrow, having sporangia on both sides.

Schizæa, Smith, is a small widely-diffused genus, very distinct in habit. Other genus, *Anemia*, Sw.

Order VII.—Gleicheniaceæ.

The sori are dorsal, without indusium; sporangia sessile, usually two to ten in each sorus; the annulus is complete, transverse or oblique; dehiscence longitudinal.

Order VIII.—Hymenophyllaceæ.

This order contains the lowest forms of ferns, most nearly allied to the mosses; they are small, often epiphytic; the sporangia have an oblique or transverse complete annulus, and therefore burst with a longitudinal slit; they are formed on a prolongation of the fertile vein projecting beyond the margin of the leaf, which is surrounded by a cup-shaped indusium. The genus *Hymenophyllum*, Smith, contains small, sometimes very minute ferns, frequently found growing on trunks of trees and damp rocks; the fronds are of delicate texture, often of an olive-green colour. The *Trichomanes*, L., agree with the last in habit of growth and delicacy of texture; the shape of the involucre is characteristic.

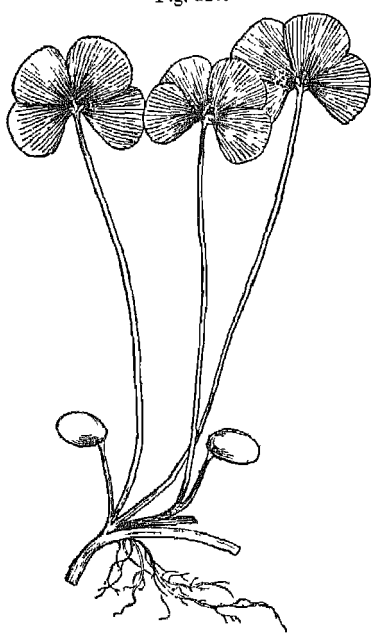
Order IX.—Marsiliaceæ.

In the asexual generation, these plants are perennial, creeping in mud; the microsporangia and macrosporangia are contained in the same sporocarp. The sporocarp has somewhat the form of a bean, the stalk running up one of its edges; the interior of the sporocarp is divided into

compartments, each containing a sorus, the placenta of which extends on its external face from the dorsal to the ventral edge of the sporocarp and projects inwards in the form of a ridge along the centre; the placenta bears a row of macrosporangia, and on either side of this, a row of microsporangia.

The sporangia must be considered as metamorphosed leaves with united pinnæ, and bearing the sporangia on their upper sides in a definite relation to the course of the veins, in the same manner as among the ferns.

Fig. 221.



Marsilea quadrifolia, with two sporocarps.

Beneath the epidermis of the wall of the sporocarp, which is at first very hairy, lie two or three layers of thickened and lignified cells, which form a very hard sporocarp-wall, scarcely permeable by water.

Marsilea quadrifolia, Roxb. (Sùsneshàk), is very common on the borders of tanks and marshy places; the leaves have long petioles, with four leaflets at the summit. The leaflets are broad obcordate, entire, resembling the leaflets of Oxalis or Trifolium.

Order X.—Salviniaceæ

Are annual plants floating in water; the microsporangia and the macrosporangia are formed in different sporocarps, which are the metamorphosed teeth of the submerged leaves. A resemblance can thus be traced between the sporocarp of Salvinia and the indusiate sorus of Hymenophyllaceæ. In Salvinia the wall of the sporocarp is thin and delicate.

Salvinia imbricata, Roxb. (Pana), is a floating ramous plant, trapeziform; the leaves are sessile, alternate, and imbricated; the sporocarps are situated between the roots, on the underside of the plant, and are covered by imbricated scales. *S. cucullata*, Roxb., is a small floating ramous plant; the leaves are opposite subsessile, cowl-shaped. *S. verticillata*, Roxb., is a floating plant; the leaves are opposite petioled, oval, flat; the sporocarps are formed on the underside of the plant between the insertion of the leaves, surrounded with long hairy trichomes. In *S. hispida*, the leaves are orbicular, cordate. *Azolla pinnata*, R. Br., is a pinnately branched plant, with minute leaves; it differs from the Salvinia in having no true roots. All the Salvinias are common in Bengal during the rains.

Order XI.—Equisetaceæ.

In the asexual generation, the Equisetaceæ consist of herbaceous plants (horse-tails) with jointed rhizomes, and fistular jointed stems, with sheaths formed by the coalescence of the leaves at their base; the stems are verticillately branched at the joints; their vegetative organs have a resemblance to the dicotyledonous order Casuarineæ.

The fibro-vascular bundles are arranged in a circle, between the central and cortical air-cavities; these bundles ascend in a vertical direction and parallel to one another through the internodes; a quantity of silica is deposited in the stems, and especially in the epidermis. In their mode of reproduction, the Equisetaceæ closely resemble ferns.

The sporangia of Equisetaceæ are outgrowths of peculiarly metamorphosed leaves, and are generally formed in numerous whorls, at the summit of ordinary shoots, or of those specially destined for this purpose; the spores have three coats,—the first formed coat is capable of swelling; it splits subsequently into two spiral bands forming the so-called *elaters;* a second and third coat soon afterwards make their appearance within it: all three lie at first closely one upon another like successive layers of a single coat; but when the spore is placed in water, the outer one swells up strongly and becomes detached from the others, and at the same time its division into elaters is first indicated, which by their hygroscopic properties assist in

the dissemination of the spores. The spores are highly organized, containing a nucleus and chlorophyll granules. The *sexual generation* arises from the spores, which when sown in water, or on damp soil, show the preparatory phases of germination after only a few hours, and consist of *independently existing* usually *dicecious prothallia;* upon the prothallia are produced the antheridia and archegonia; in the antheridia are developed a number of eventually motile antherozoids; in the archegonia, a single central cell, containing an oosphere, which after fertilization develops into a young plant.

The Equisetaceæ at present existing consist of a single genus *Equisetum*. *Equisetum debile*, Roxb., is the commonest species of Equisetum in India; it grows abundantly in the plains and in the Himalayas. *E. diffusum*, Don., is a plant common in Northern India; the stem and branches are slender; the latter, from three to five inches long; the whole plant is about eighteen inches high. *E. elongatum*, Willd., is a taller plant than *E. diffusum;* the branches also are not so long; it grows in North-western India. *E. arvense*, L., is from six to eight inches high; the axis is very succulent. In *E. variegatum*, Schl., the nodes are of a bluish colour. *E. limosum*, L., the smooth naked horse-tail is also to be found. *Calamites* and other plants referable to this order occur in the Goudvána, and carboniferous formations of India and Europe.

Fig. 222.

Portion of a stem of an *Equisetum* with sporangia.

Order XII.—Selaginellæ.

The asexual generation are terrestrial plants, bearing small heart-shaped leaves arranged in four nearly vertical rows, and are of *two sizes;* the repeatedly dichotomizing branches are densely covered with them. (See modes of branching, page 15.) The sporangia are shortly stalked,

roundish capsules, arising from the base of the leaf or from the stem itself.

The Selaginellæ are cultivated for the elegance of their foliage. *Selaginella verticillata* is a plant somewhat resembling the stag-horn moss in appearance, but of a more delicate green colour. *Selaginella bi-color* is a trailing plant, very common in the gardens about Calcutta; the leaves, particularly during the rains, have a peculiar metallic lustre, in which dark blue, bronze, orange, and pale green are beautifully blended. *S. caudata*, Spring, is a large handsome plant. *S. Jacque montis*, Spring, is a small plant common in the Himalayas; many other species are to be found in the Himalayas and Burmah.

Order XIII.—Isoeteæ

Are in the asexual generation, aquatic plants, with long grass-like leaves; the stem is distinguished by its extraordinary small growth in length; the leaves have broad bases of insertion, and do not leave between them any surface of the stem bare. The sporangia do not dehisce, but the spores escape by the decay of the wall.

Isoetes capsularis, Roxb., grows in deep standing water with Valisneria spiralis; the leaves are delicate, from two to three feet in length, only about a quarter of an inch broad, and are slightly serrated near the apex. The sporangia are produced from the leaves and are heart-shaped.

Order XIV.—Lycopodieæ

Are terrestrial plants with small usually closely imbricated leaves, of *one size;* the sporangia are reniform and arise in the axils, or at the base of the upper surface of the leaves, and are larger than those of the ferns; they contain tetrahedral spores of one kind only; they split when mature into two valves at the apex, or on the anterior surface.

The prothallia are developed underground and are monœcious. The genus Lycopodium includes a very large number of species common in India, principally in the Himalayas and mountains of Southern India. *L. clavatum*, L., is one of the commonest species. Thirteen Indian species

are represented in the Herbarium at the Royal Botanical Garden, Shibpur.

The *Lepidodendra* are fossil Lycopods described by Hugh Miller as "great plants of the club-moss type, that rose from 50 to 70 feet in height."

Order XV.—Psilotea

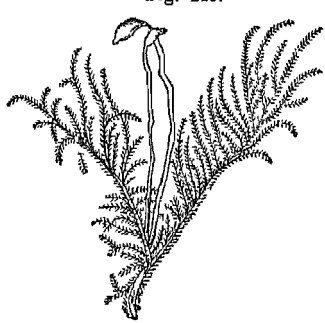
Are plants with long slender, many forked stems, and very small rudimentary leaves; true roots are altogether wanting. Example: *Psilotum triquetrum*, Swartz.

GROUP II.—MUSCINEÆ.

The mosses and liverworts, which are comprised under the term Muscineæ, resemble the vascular Cryptogams in the fact that their life history consists of a sharply defined alternation of generation, a sexual (the moss) and an asexual. This last structure, when observed externally, appears simply as a fruit; it is hence called indifferently fruit, or sporogonium, and is destined for the production of asexual spores.

When the asexually produced spore germinates, it gives rise in most of the Hepaticæ immediately to the sexual generation; in all the mosses and a few Hepaticæ a confervoid thallus is first formed called a *protonema*, from which the sexual generation develops. The sexual generation, unlike that in vascular Cryptogams, is largely developed, and forms the plant commonly known as a *moss* or *liverwort*. The sexual generation is either a flat leafless thallus, as in most liverworts, or a slender leafy stem, often much branched, as in most mosses. In most cases, the thallus or the apex of the leafy stem continues to grow, while the older parts die off; in this manner, the branches finally become independent plants,

Fig. 223.



A moss (Hypnum) showing the leafy portion (sexual generation) and fruit-like structure (asexual generation) in which the spores are formed.

and this, as well as multiplication by gemmæ, &c., serves not only to increase the number of individuals, but is also the immediate cause of the social mode of growth of these plants. In this manner many mosses, such as Sphagnum, Hypnum, &c., form dense masses extending over considerable areas.

The sexual organs of the Muscineæ are *antheridia* (male) and *archegonia* (female). The mature antheridium is a body with a longer or shorter stalk of a spherical, ellipsoidal, or club-shaped form, within which the *antherozoids* are formed, which are spirally coiled threads, thicker at the posterior, and tapering to a fine point at the anterior end, at which are placed two long fine cilia, the vibrations of which cause motion. The female organs (the archegonia) are, when in a condition capable of being fertilized, serai-shaped bodies bulging from a narrow base and prolonged into a long neck; they contain within the cavity the *oosphere* or female cell. The antheridia and archegonia are usually produced in great numbers in close proximity. In the thalloid forms of the Hepaticæ, they are generally enveloped by later outgrowths of the thallus. In mosses and some Hepaticæ, several archegonia are commonly surrounded by an envelope formed of leaves, which is termed the *perichætium*. In the mosses the antheridia are frequently collected in inflorescence-like structures either with the archegonia or in a monœcious or dicœcious condition.

The asexual generation or sporogonium arises in the archegonium from the fertilized oosphere. It forms a cellular body which causes the expansion of the original wall of the archegonium. After a time the wall gives way in the mosses by a circumscissile dehiscence, so that the upper part is carried upwards, ultimately becoming the *calyptra* of the sporogonium. Its behaviour supplies distinctive characters for the larger groups. In the lower Hepaticæ the sporogonium remains always enclosed in the calyptra; in the higher Hepaticæ, it protrudes only after the ripening of the spores. As the sporogonium grows, it becomes differentiated into a slender stalk or *seta* and a *capsule* or *urn* or *theca* in which the spores arise.

The mode of development of the spores of Muscineæ

agrees in the main points with that of the pollen of Phanerogamia; the layers of the tissue, which produce the spores, after multiplying to a certain extent, form free cells from the whole contents of each cell; each of these cells become divided into four, and each of these four new cells produces a single free cell from its whole contents. These last formed cells, set free by the solution of the enclosing membrane, are the spore cells, which when ripe are often marked with points or recticulations like pollen-grains. The ripe spores have a thin cuticle (the exospore) provided with small excrescences which is ruptured on germination by the inner layer of the cell-wall (endospore). The differentiation of the tissue of Muscineæ is not so considerable as in vascular Cryptogams; fibro-vascular bundles are not formed, only in the stem, and leaf-veins of the more perfect mosses, is an axial bundle of elongated cells differentiated, which may be considered as a slight indication of the fibro-vascular system.

The Muscineæ are divided into two classes: 1*st*, Musci (mosses), and 2*nd*, Hepaticæ (liverworts).

ABSTRACT OF ORDERS OF MUSCINEÆ.

MUSCINEÆ
- Musci (Mosses)
  - Bryaceæ. Ex.: Feather Moss.
  - Phasaceæ. Ex.: Earth Moss.
  - Andreaceæ. Ex.: Andrea.
  - Sphagnaceæ. Ex.: Bog Mosses.
- Hepaticæ (Liverworts)
  - Jungermanniceæ. Ex.: Liverworts.
  - Marchanticeæ. Ex.: Marchantia.
  - Monocleæ.
  - Ricciceæ. Ex.: Waterworts.
  - Antnocerotceæ. Ex.: Nardoo.

Berkeley divides mosses into five groups:

1. Pleurocarpi	}	Bryaceæ.
2. Cladocarpi		
3. Acrocarpi		
The group Phascei of Acrocarpi	...	Phasaceæ.
4. Schistocarpi	...	Andreaceæ.
5. Syncladei	...	Sphagnaceæ.

Many of the mosses and liverworts are cosmopolitan. For particulars of these plants, see Berkeley's Handbook of British Mosses. See also Hooker and Taylor's Muscologia Britannica, 1827; Australian mosses, Mueller, 1864; Bryologia Britannica, Wilson; "mosses of the East Indies,"

Mitten, Journal of the Linnæan Society, iii, 1859 (Supplement); and Synopsis Muscorum Frondosorum, Müller. For the minute structure of the Muscineæ, see Sachs' Text-book of Botany, translation by Bennet and Thistleton Dyer.

Class I.—Musci.

In mosses, the *sexual generation* is developed from the spore with the intervention of a *protonema*, often densely filamentous, and consists of filaform stems, furnished with leaves in two, three or four rows, usually without any bilateral structure, and generally branching in a monopodial, never in a dichotomous, manner (modes of branching, see page 15).

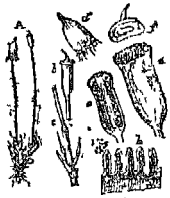
In most mosses, the protonema disappears after it has produced the leafy stems as lateral buds; but where these latter remain very small and have only a short term of life, as in the Phascaceæ, &c., the protonema still remains vigorous after it has produced the leafy plants, and when the sporogonium has already been developed upon them. In such cases, all three stages of the cycle of development are present simultaneously in genetic connection.

The leaf-bearing plant, which afterwards produces the sexual organs, originates from the lower cells of the lateral branches of the protonema. "The sexual organs of mosses usually occur in considerable numbers at the end of a leafy axis surrounded by enveloping leaves often of peculiar shape; a compound structure of this kind may, for the sake of brevity, be called a '*Flower*.' Within a flower, either both antheridia and archegonia are produced, or it contains only one kind of sexual organ. The flowers may then be either monœcious or dicœcious;" the antheridia are, when mature, stalked sacs with a wall consisting of a single layer of cells; in most mosses they are of an elongated club-shape. The archegonia consist, when mature, of a moderately long base, which supports a roundish ovoid ventral portion; above this rises a long thin neck.

The *asexual generation*, or sporogonium, is formed in the archegonium. After impregnation, the oospore develops into the sporogonium, within the archegonium, which latter grows with it and becomes the *calyptra*. Although growing

within the tissue of the sexual generation, the spore-case has no organic connection therewith. Within the sporogonium (*theca* or *urn*) a number of spores are formed, and when they are mature, the stalk (seta), or pedicel, rapidly becomes elongated, thus throwing off the calyptra (veil); the neck of the archegonium, the wall of which assumes a deep red brown colour, still for some time crowns the apex of the calyptra. A large part of the central tissue of the capsule remains sterile as the so-called *columella;* the upper part (operculum) of the capsule usually becomes detached from the lower part (the urn) in the form of a lid, in order to allow the spores to escape.

Fig. 224.



The capsule with operculum, &c., of *Polytrichum.*

"The vegetative reproduction of mosses is more copious and varied than is the case in any other section of the vegetable kingdom. It presents the peculiarity that the production of a new leaf-bearing stem is always preceded by the formation of a protonema, even when the propagation takes place by gemmæ (see page 15). Exceptions are afforded only by the few cases in which leafbuds become detached, and commence immediately to grow." In some species, it is sufficient to keep a tuft of moss damp for some days, and turned downwards, in order to produce hundreds of new plants in this manner.

No plants are so easy to prepare for the herbarium as mosses; they easily part with any moisture which they have imbibed, and if common care is used, they are not liable to be spoiled by damp or seriously injured by the depredation of insects.

Abstract of Orders of Mosses.

Mosses may be distributed naturally into four parallel orders:

Bryaceæ.	Andreæaceæ.
Phascaceæ.	Sphagnaceæ.

Order I.—Bryaceæ

Are mosses, with small and scale-like leaves, usually spirally arranged. The sporogonium is always stalked,

and the seta is usually of considerable length. The theca is covered by a calyptra, and opens by throwing off an operculum. The Bryaceæ include a large number of genera.

Order II.—Phascaceæ

Are small mosses, and may be considered as the lowest form of the Bryaceæ. They are usually found covering the earth with a green crust, which ultimately develop into tiny plants. The short stems remain attached to the protonema, until the spores are ripe. The sporogonium (urn) does not open by an operculum, but allows the escape of the spores only by its decay.

Order III.—Andreæaceæ

Are small tufted mosses with blackish red foliage, which gives them a burnt-up appearance; they are very leafy and much branched, the leaves being imbricated in eight rows. The sporogonium has constantly a terminal position on the stems of the sexual plants, and sessile on a slightly elongated stalk-like receptacle: the ripe theca does not open by an operculum, but by four longitudinal slits at the side; this last peculiarity is characteristic of the order.

Order IV.—Sphagnaceæ

Are aquatic plants of cold and temperate climates, with peculiar yellowish green aspect, imbricate leaves, and fasciculate branches. The sporogonium (urn) is sessile on an often much elongated receptacle (pseudopodium). The sporogonium dehisces by an operculum and is destitute of a peristome. In the sporogonium two kinds of spores are produced, the larger of which only germinates. The Sphagnaceæ include only a single genus.

Class II.—Hepaticæ.

The *sexual generation* arises direct from the spore, or from a rudimentary pro-embryo developed on a dichotomously branched (see modes of branching, page 15) thalloid stem; the mode of growth is distinctly bilateral. In the

greater number of families and genera the vegetative structure is a broad, flat or curled plate of tissue. The leaves of all foliose Hepaticæ are simple plates of cells, in which even the mid-rib usual in the leaves of mosses is always wanting.

The *asexual generation* or sporogonium remains surrounded by a *calyptra* (the ventral portion of the archegonium) until the spores are ripe. The mother-cells of the spores arise from the whole of the internal cells of the sporogonium, or the intermediate cells become developed into elaters. The spores escape through the dehiscing of the capsule in valves. The external form and internal structure of the sporogonium are very different in the different groups. The propagation by gemmæ is very common and characteristic; the sexual organs are formed in the thalloid forms, on the upper side exposed to light. In the foliose forms the origin of the antheridia and archegonia is very various, and they are also developed in different ways. The antheridium consists, in the mature state, of a pedicel surmounted by a globular or ellipsoid body.

Abstract of Orders of Hepaticæ.

The Hepaticæ are usually divided into five orders, *viz*:

1. Jungermanniæ.
2. Marchantieæ.
3. Monocleæ.
4. Ricciæ.
5. Anthoceroteæ.

Order I.—Jungermanniæ

Are plants with distinct stem and leaves imbricated in a distichous manner, which gives a flattened character to the branches; the sporogonium (capsule) bursts into four valves and contains elaters.

Order II.—Marchantieæ

Are small green plants, with a thalloid stem, in the form of a lobed leaf-like cellular expansion. The sporogonia are collected on a stalked organ, and burst by four valves; they contain elaters.

Order III.—Monocleæ.

This order contains transitional forms between the Anthocerotæ and Jungermannieæ. The long sporogonium has a longitudinal dehiscence, and no columella. The first, or sexual generation, is either thalloid or foliose.

Order IV.—Ricciæ.

In these plants the thallus is leaflike, and floats on water, or in some species is terrestrial and attached by root-hairs. The sporogonium is imbedded in the thallus, and does not project above it; it is indehiscent and contains no elaters. The spores escape on the decay of the surrounding tissue.

Order V.—Anthocerotæ.

The thallus is flat and irregularly branched. From the archegonium springs a pod-like capsule, which dehisces longitudinally into two valves when ripe. A columella is present; the elaters have no spiral bands.

Details of Orders of Muscineæ.

Order I.—Bryaceæ.

The Bryaceæ, or true mosses, are very plentiful in India, particularly in the hills. In these plants the sporogonium is always stalked, and the seta is usually of considerable length; the theca always opens by an operculum, which is either simply detached from the upper part of the theca, or a layer of epidermal cells (annulus) is thrown off with the operculum. The opening of the theca is mostly furnished with appendages, separately termed *teeth*, or collectively *peristome*. If the peristome is wanting, the sporogonium is *gymnostomous*.

The genus *Polytrichum* (hair-mosses), to which the largest and most highly developed mosses belong, differs from the other genera in several points in the structure of the theca. The teeth of the peristome are composed of thickened prosenchymatous cells arranged in bundles of a horse-shoe

shape. The teeth are from 32 to 64 in number. When the operculum is thrown off, a layer of cells remains uniting the points of the teeth. The genus *Dicranum* (fork-mosses) include a large number of species. *D. palustre* is a large handsome moss, with yellow, green glossy foliage; the leaves are broad at the base with serrated edges; the urn is nearly erect, chestnut coloured, and has a beaked operculum. The genus *Tortula* (screw-mosses) have long narrow urns growing on erect seta (stalks); the teeth are long and slender, and twisted round the columella (pillar in the centre of the urn); the operculum (lid) is long and beaked. These mosses are very common, particularly in the hills. The genus *Grimmia* comprises a large group of tufted mosses, growing on rocks; erect when small, prostrate when mature; the operculum is convex and slightly pointed. The columella falls away with the operculum (as limited by some botanists the columella does not fall away but shrivels within the urn). The hair-mosses, *Pogonatum*, are very showy plants. *P. aloides* has lance-shaped dentated leaves and an oval urn; when moist the leaves are spreading, but they cling close to the stem when dry. The genus *Bryum*, or thread-mosses, are also a large group; they grow in tufts, on trees, rocks, and banks, with pear-shaped drooping urns and stem clasping leaves. *Mnium* have generally large leaves, which, when examined through the lens, are seen to be dotted and edged with a thick border. The upper leaves are larger than the lower ones, and are arranged in a star-like form; the urns are large and oval. The genus *Funaria*, or cord-mosses, have the seta very much twisted. *F. hygrometrica* flourishes on wood ashes, and almost everywhere. The bladder-mosses (*Physcomitrium*) have pear or club-shaped urns on an erect or slightly curved seta; the operculum is covered by an inflated calyptra; this last peculiarity gives the name to the genera. The flat forked-mosses (*Fissidens*) are numerous; they are very small plants; the leaves are placed alternately on either side of the stem, which sometimes gives them the appearance of minute ferns; the operculum is mitre-shaped. *Anomodon* is commonly found growing on the roots of trees and of rocks; it has long branches interlacing one another. The genus *Leskea* are feathery mosses with oval urns, on erect

stems, which peculiarity distinguishes them from the genus *Hypnum*, the true feather-mosses, which have curved seta; the urns also are generally slightly bent. Other genera are: *Leptotricum, Trematodon, Dicranella, Barbula, Rhacomitrium, Philonotis, Meteorium, Stereodon, Neckera*, &c. (For further particulars, see authorities named, page 246.)

Order II.—Phascaceæ.

The Phascaceæ are small mosses, the theca is without an operculum, and the spores escape on the decay of the sporogonium. These earth mosses are very small, covering the ground with a green crust at first. They die away in a short time. The capsules have little or no stalks. The leaves are generally in eight rows, and the whole plant is wonderfully minute.

Order III.—Andreæaceæ.

These mosses are in India, found only at considerable elevations in the Himalayas. They are small cæspitose plants, very leafy and much branched with blackish red foliage, which gives them a burnt appearance. This curious order of mosses has some striking points in common with the Jungermannieæ, particularly in its 4-valved capsule and irregularly torn calyptra; thus connecting the Hepaticæ with the Musci. The capsule has, however, a central columella, and is terminated by an evident, though persistent, operculum.

Order IV.—Sphagnaceæ.

The Sphagnaceæ include only the single genus *Sphagnum*. The stem in these plants is repeatedly branched, and these again are much divided. The urns are globular (without a peristome) placed on very short seta. Sphagnum in India is only found in the hills. Mr. J. S. Gamble, who has made a large collection of mosses at Darjiling, informs me that he only once found a Sphagnum in that neighbourhood, and that at the summit of Tonghoo, 10,000 feet elevation. The epidermal tissue of the stem, &c., is provided with broad thin-walled empty cells, which

serve as a capillary apparatus for the plant through which the water in which it grows is raised up and carried to the upper part, hence it results that the Sphagna, which always grow erect, are penetrated with water to their very summits like a sponge, even when their tufts stand high above the surface of the water.

Order V.—Jungermanniæ.

The greater number of the plants of this order form slender filiform stems with numerous sessile leaves; these leaves are sometimes arranged in two rows, situated on the upper side as in Radula. Usually, however, we find three rows of leaves, one being developed on the under or shaded side (Amphigastria), the other two rows on the upper side. The principal genera are: *Jungermannia, Plagiochila, Lepidozia, Mastigobryum, Calypogea, Radula, Madotheca, Lejeunia,* and *Frullania.*

Order VI.—Marchantieæ.

The Marchantieæ are minute green plants with a thalloid stem extending flat upon the ground; the underside produces a number of root-hairs, the upper side is covered by a very distinctly differentiated epidermis having large stomata of peculiar form. The antheridia and archegonia are borne on separate stalked receptacles, which should not be confused with the sporogonia of other groups. The principal genera are: *Marchantia, Dumortiera, Grimaldia,* and *Fimbriaria.*

Order VII.—Monocleæ.

The Monocleæ contain transitional forms between the Jungermannieæ and the Anthoceroteæ.

Order VIII.—Ricciæ.

The Ricciæ are minute plants found floating in water, among Lemna, or rooting in the ground.

Order IX.—Anthoceroteæ.

These plants, which grow on loamy ground, have a perfectly leafless flat thallus; its irregularly developed rami-

fications forming a circular disk. In *A. punctatus*, adventitious shoots proceed from the margin of the thallus, and also from the upper surface.

GROUP III.—THALLOPHYTA.

Under this term are comprised Algæ and Fungi (Lichens being also included in the latter section).

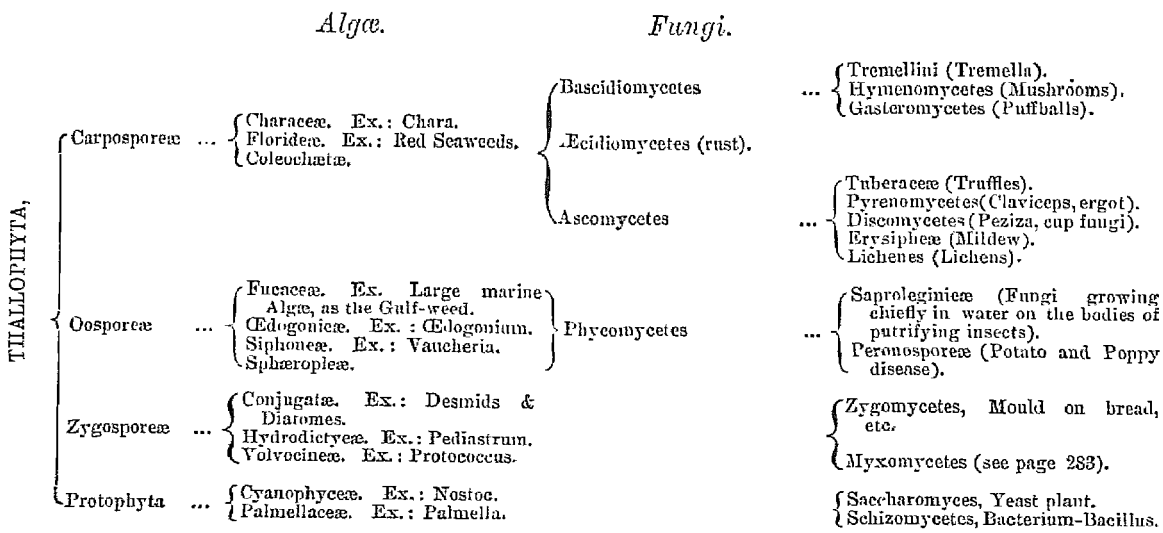
The term Thallophyte is an adequate one, in so far as it points out one prominent property of the external conformation of most Algæ and of all Fungi; but a sharp boundary line cannot be drawn in this respect between the Algæ and Fungi and the group Muscineæ.

The cellular structure of the plants of this group is their principal bond of connection; and their most striking character of distinction from the higher Cryptogams; the extraordinary variety of the forms and mode of life of the *Thallophyta* render it impracticable to characterize them collectively by giving a prominence to any other special feature of their growth or reproduction, especially alternation of generation, as may be done in the higher groups of the Cryptogamia.

The lower forms of the two divisions of the Thallophyta are very closely connected on account of their great simplicity of organization, which excludes the possibility of many different characters; it is therefore impossible to lay down accurate lines of demarcation between these two divisions: it may, however, be stated broadly that *Algæ contain chlorophyll*, and are therefore able to assimilate inorganic substances; while, on the other hand, *Fungi contain no chlorophyll*, and are therefore unable to make use of unassimilated food materials, but are found to live as parasites in other organisms, or on organic remains.

In arranging the two divisions of the Thallophyta, it is perhaps best to follow the classification adopted in the fourth edition of Sachs' "Lehrbuch der Botanik," in which Algæ and Fungi are arranged under four classes, dependent on the nature of their reproductive organs, each class consisting of two parallel series; the first series (Algæ) containing chlorophyll, the second series (Fungi) containing none. (See Sachs' Text-book of Botany, translated by Bennet and Dyer.)

Abstract of Orders of Thallophyta.



Abstract of Orders of the Cryptogamic Group.

Thallophyta.

Class I.—Carposporeæ.

The result of the fertilization of the female organs by the antherozoids is the production of a fruit-like body, in which a number of cells, besides the true reproductive cells, take part, and in which are produced the carpospores, which ultimately germinate.

Order I.—Characeæ

Are submerged fresh-water plants with verticillately branched stems, the ultimate branchlets resembling linear leaves. Reproductive organs, nucules (female organs), and globules (male organs).

Order II.—Florideæ

Are marine Algæ, mostly of a red or violet, rarely of an olive, purple, or brownish colour; form variable. They are propogated sexually by means of carpospores formed in capsular fruit-like cells. The antherozoids are not endowed with independent motion.

Order III.—Coleochæteæ

Are minute fresh-water green Algæ, constructed of branched rows of cells attach-

Order I.—Basidiomycetes

Are Fungi growing on dead organic matter. From the mycelium (a structure developed from the spore) is produced the asexual generation, which is ordinarily called the mushroom or receptacle, usually bearing quaternary asexual spores at the apex of erect basidia (projecting portions of the Fungus).

Order II.—Æcidiomycetes

Are Fungi parasitic on living plants; the carpospores are developed from the mycelium beneath the epidermis of the leaf. The fruit-like structure (æcidia), when mature, breaks through the epidermis of the leaf, and forms an open cup, in which the spores are produced.

Order III.—Ascomycetes.

The asexual generation comprises a greater variety of forms than any other

ed to the submerged parts of other plants, and forming circular discs. The carpogonium is always the terminal cell of a branch. They produce swarmspores.

Order III.—Siphoneæ

Are plants living on damp earth, or in water, consisting of a single though much branched tubular cell; the order of Fungi. The common characteristic by which all the different forms are connected, is the ascxual formation of spores in the interior of sacs (asci).

Class II.—OOSPOREÆ.

Reproduction takes place by oospores (fertilized oospheres) resulting from the fertilization of a large oosphere (female or germ-cell) by minute antherozoids (male or sperm-cell).

Order I.—Fucaceæ

Are olive-coloured seaweeds of a cartilaginous texture, usually attached to rocks by a discoid base. The oospheres are set free by the bursting of the oogonia, and are fertilized outside the plants by the antherozoids, and the fertilized oosphere at once develops into a new individual.

Order II.—Œdogoniceæ

Are fresh-water filamentous Algæ, usually attached to the submerged parts of other plants. The thallus consists of unbranched or branched rows of cells. The spermatozoids and oospores are formed in the cells of the filaments.

Order I.—Phycomycetes

Are unicellular filamentous colourless parasites. This order may be divided into two sub-orders—the *Saprolegnieæ* and the *Peronosporeæ*. The plants in both sub-orders form spherical oogonia (special organ of the mother plant in which the germ-cell lies) at the end of the mycelium structure, in each of which one or more oospores result from fertilization.

The Saprolegnieæ mostly grow on the bodies of insects putrifying in water.

The Peronosporeæ live in the interior of Phanerogams; the branches of their unicellular mycelium growing between the cells of the tissue from which they draw their nourishment, as in the tubers of the potato.

free part of the cell that does not penetrate the ground contains a parietal layer of protoplasm with abundance of chlorophyll, but forms no nucleus.

Order IV.—Sphæropleæ.

A group of green filamentous Algæ.

Class III.—Zygosporeæ.

In this class the reproduction takes place by the union of two apparently similar cells. The class may be divided into two divisions according as the conjugating cells are motile or stationary. The product of the coalescence surrounds itself with a firm cell-wall, and is termed a *zygospore;* which generally germinates only after a long period of rest.

Conjugating Cells Stationary.

Order I.—Conjugatæ.

In the *Mesocarpeæ* and *Zygnemeæ*, conjugation takes place between cells belonging to distinct unbranched filaments. In *Desmidieæ* and *Diatomaceæ*, between isolated cells.

Order I.—Zygomycetes.

Infest dead or dying parts of plants, especially fleshy fruits, which quickly decay in consequence of their attacks; the mycelium is unicellular, and much branched.

Conjugating Cells Locomotive.

Order II.—Hydrodictyeæ

Are fresh-water plants, distinguished by forming a large number of swarm-spores, which, when they come to rest, unite into a single family; net-like in Hydrodictyon, tubular in Pediastrum.

Order II.—Myxomycetes.

These plants consist in their vegetative condition of masses of naked protoplasm (plasmodia), which possess a creeping motion on the substratum of decaying matter, earth, &c., on which they grow.

Order III.—Volvocineæ

Are microscopic Algæ living in colonies, which, during the whole of their vegetative period, are continually in motion, the motion, as is usually the case with swarm-spores, being caused by two cilia.

Class IV.—PROTOPHYTA.

No sexual mode of reproduction is known in these plants; propagation takes place by fission only.

Order I.—Cyanophyceæ

Are unicellular Algæ of thread shaped, or moniliform rows of cells, usually simple, rarely branched, enclosed in gelatinous sheaths, by which they are united into large colonies. They live in water and damp places.

Order I.—Saccharomyces

Are Fungi consisting of branched rows of roundish or ellipsoid cells which grow in saccharine fluids; and in growing cause the decomposition of the fluid with formation of alcohol, &c.

Order II.—Schizomycetes

Are most minute organisms, spherical and solitary, or rod-like, and united in filaments, characterized by the ease with which they break up into separate cells, as soon as they come into contact with the atmosphere.

ALGÆ.

The Algæ are cryptogamic plants living in water or in damp places exposed to the light, always containing chlorophyll; they are extremely variable as to form, size, and colour. They include some of the smallest and simplest forms of the vegetable kingdom, rising in other instances to a high degree of organization and considerable dimensions. The development of the mass of Algæ is attained in

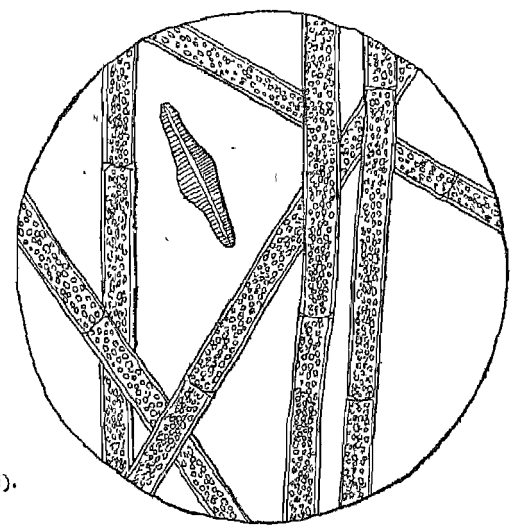
different ways,—sometimes the single individuals increase, as occurs in the most perfect forms, Characeæ, &c.; at other times numerous individuals are united into a genetic and organic whole, which behaves as an individual, as in the gelatinous Algæ (Nostocaceæ, &c.); they are all, however, exclusively cellular in structure and destitute of stomata.

In the cells of the lowest forms of this division nothing more can be recognized than a cell-wall containing a coloured protoplasmic substance; the latter always possessing a vacuole (fluid sap separated in the form of drops). A nucleus absent from the lower forms, is clearly present in

Fig. 225.

Spirogyra (magnified).

Fig. 226.



A common filamentous Alga (Œdogonium) found abundantly in fresh water tanks, also a unicellular Alga (Diatome).

the higher; the green protoplasmic substance sometimes forms granules, sometimes broad bands, often curved spirally, as in Spirogyra, sometimes discs, the forms of which are characteristic of particular genera.

The shape of the cell-wall is much less varied than in other classes of plants; the cell-walls of Algæ have a great tendency to become converted into a mucilaginous sub

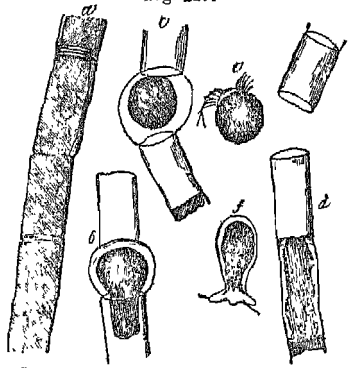
stance. In the Diatomaceæ, great firmness of the cell-wall is obtained by the deposition of silica.

The mode of combination of the cells with one another is more various among Algæ than in any other class of plants; they are frequently arranged in a single row, or they form a flat surface, only one cell thick, or finally in the more highly developed forms of Algæ, such as in the various species of Characeæ, Fucus, Sargassum, &c., they exhibit the usual mode of formation of tissues which here makes their appearance for the first time in the vegetable kingdom; the outermost layer of cells being smaller and firmer, while the inner cells are often very large, and sometimes extremely long: and the entire process of growth is governed by a single apical cell.

The external differentiation of the Algæ in their higher forms resembles the difference that exists between stem and leaf, and to a certain extent even of roots. True roots, however, provided with a rootcap are altogether wanting (see section root, page 3). Sachs terms these leaf-like appendages *Phylloids*, and the root-like appendages *Rhizoids*.

The reproduction of Algæ is effected in a number of different ways; asexual reproduction is known in all the classes, sexual generation in the three higher; in numerous cases an alternation is found between asexual and sexual generations. The lowest forms multiply by dividing into a number of cells or segments; this is the only mode of reproduction known in the *Cyanophyceæ* and *Palmellaceæ*; it is also very common amongst the Desmidieæ and Diatoinaceæ.

Fig. 227.



Development of swarmspores of Œdogonium: *a*, a filament; *b* and *c*, joints breaking across to emit their contents; *d*, empty cell; *e*, swarmspore; *f*, young Œdogonium (after *Henfrey*).

Another remarkable form of asexual reproduction, which extends from the lowest up to the highest Algæ, is that known as reproduction by *swarmspores* or *zoospores*; these result from the contraction of the protoplasmic substance

of certain cells, which are then reconstructed, escape through an opening in the wall of the mother-cell, and then swim about in the water for a longer or shorter time, like infusoria (the lowest class of animals), by means of two, four, or more cilia; they are microscopic and destitute of a cell-wall. After moving about for some time, the zoospores lose their cilia, become encysted, and grow into new Algæ; they occur in both fresh and salt water.

In the Florideæ (red seaweeds) a kind of gemma (see section bud, page 15) is formed termed a *tetraspore*, which consists of a parent cell divided into four chambers, the contents of which when set free from the parent plant grows up at once into new plants.

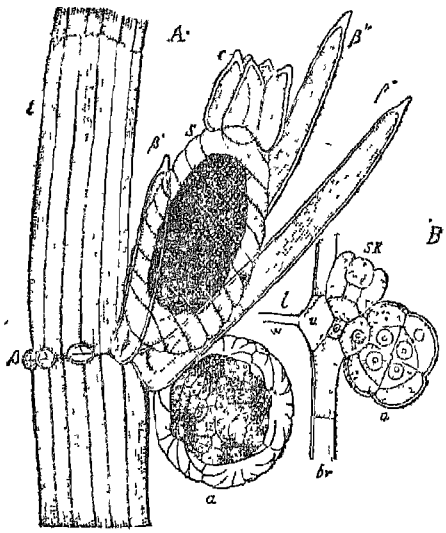
Sexual reproduction is brought about in different ways, the most important distinction being that the sexual cells may be either similar or dissimilar in size; in the former the reproduction is termed *conjugation;* this occurs in the class Zygosporeæ; in the latter, *fertilization* or *impregnation*, the fertilizing body being termed a *spermatozoid, antherozoid, sperm* or *male cell*, the mass of protoplasm which has to be fertilized, an *oosphere, germ,* or *female cell.* The spermatozoids are formed in cells called *antheridia,* and when first emitted from these cells, are usually endowed with a power of locomotion; the female reproductive bodies or oospheres are formed in cells termed *oogonia.* In many sections of Algæ, especially in the fresh-water species, the mode of reproduction varies according to the generation (see page 225).

The chlorophyll in Algæ is frequently concealed by the presence of substances of a different colour. Fresh-water Algæ are mostly green, and are found plentifully in any stagnant water. Marine Algæ (for naming seaweeds, see Harvey's Algæ of the Southern Ocean, 1847) are chiefly of a brown, red, or olive colour; they are sometimes very large, and occur in great masses, particularly Sargassam bacciferum, which forms the celebrated masses of gulf-weed in the Atlantic Ocean.

Characeæ.

The Characeæ are submerged fresh-water monœcious or dicœcious plants, rooting in the ground and growing erect; they have verticillately branched stems, the internodes of

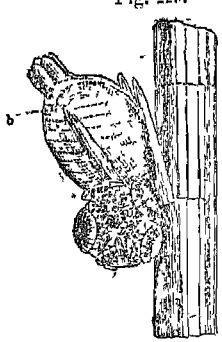
Fig. 228.



Chara fragilis (after *Sachs*).

which (in Chara) consist of a central or axile cell surrounded in a spiral manner by other cells (see Fig. 228) which form a cortex

Fig. 229.



A *nucule* in a monœcious Chara standing above the globule.

The reproductive organs are of two kinds,—to the male organs the term *globules* is given, while the female organs are called *nucules* (see Fig. 229). Globules and nucules stand on each side of the leaves. The globules are small globular bodies, the walls of which consist of eight flat cells, which in the ripe state are of a red colour; in the interior are a number of cellular jointed filaments, from each joint of which is developed a ciliated spermatozoid. The nucule is an ovoid body, somewhat larger than the globule. It consists of an axial row of cells closely surrounded by five tubes, which are coiled round it spirally (see Fig. 229); the whole is a metamorphosed shoot; the

oospore is developed as the result of impregnation from the large apical cell of the inner axial row.

There are only two genera, *Chara* and *Nitella*. In the Nitella each internode consists of only a single cell, while in the stem of Chara, there is a central or axial cell, surrounded in a spiral manner by other cells.

Chara verticellata, Roxb., grows in standing sweet water; it appears during the cold and hot seasons. The joints of the stem are somewhat prickly. *Chara flacida*, A. Braun, is very common in tanks and jheels in Bengal. *Nitella Roxburghii*, A. Braun (Jhang), is common in stagnant water in Bengal; the stems are smooth, and of a soft flacid texture; often several feet long. *Nitella oligospira*, A. Braun, grows in thick masses.

Florideæ

Are marine Algæ, mostly of a red or violet colour; the green chlorophyll grains being concealed by a red pigment, which can be extracted by cold fresh water.

Their sexual reproduction differs greatly from that of most other Algæ. The spermatozoids have no active motion, and are only moved about passively in the water, till they come in contact with a hair-like cell, the *trichogyne*, which is a long, thin hair-like hyaline sac, serving as a receptive organ and springing from a structure which is called the *trichophore;* near which the result of the fertilization becomes apparent; in its simpler forms this structure shows considerable resemblance to that of the Coleochætæ.

The asexual organs of reproduction take the form of *tetraspores*, which are not endowed with power of motion, and resemble in some respects the gemmæ of the Hepaticæ.

The red seaweeds are abundant in warm latitudes, occurring in deep water below tide-marks. Most of the Indian species can be found in the neighbourhood of the Andamans.

The abundant gelatinous substance of the thallus of many kinds, composed of a modification of cellulose, renders them nutritious. *Plocaria tenax*, Nees, is largely used by the Chinese for making glue. In the genus *Laurencia*, Lamx., the colour of the thallus is bright red, occasionally varying to pink or purple; the thallus is thickish, sometimes round, sometimes flattened. *Laurencia papillosa*,

Forsk.; *L. obtusa*, Hudson; *L. flagellifera*, Agh., are also common.

The *Glacelarias* are slender gelatinous seaweeds; one species is used as an article of food in Ceylon. The genus *Hyphea* are slender plants. Several species of *Gelidium* are used by the swallows of the Malayan Archipelago and Cochin China for building their famous "edible nests."

Other genera are: *Chylocladia*, Ag.; *Porphyra*, Ag.; *Amphiroa*, Ag.; *Melobesia*, Lamx.; *Grateloupia*, Wulf; *Polysiphonia*, Ag.; and *Polocamium*, Huds. *Dictyota*, Lamx.; *Padina*, Adans; and *Dictyopteris*, Lamx., may also be placed under this order; they are olive-coloured seaweeds with a continuous thallus.

Coleochætæ

Are minute fresh-water Algæ, consisting of branched rows of cells attached in standing or slowly running water to the submerged parts of other plants, and forming circular closely-attached or cushion-like discs. The name of the order (sheath-hair) is due to the circumstance that certain cells of the thallus form hairs surrounded with sheaths. "The reproduction of the Coleochætæ is brought about by asexual swarmspores and by resting oospores produced sexually." The antheridia are formed at the same time as the oogonia in adjoining cells; one antherozoid bearing two cilia is formed in each antheridium. The oogonium is always the terminal cell of a branch; the effect of fertilization is seen in the formation of the oospore. The oospore divides within the oogonium, and from the cells thus formed swarmspores escape, which grow into new individuals. Several species of Coleochætæ can be procured in Bengal. They are all microscopic.

Fucaceæ

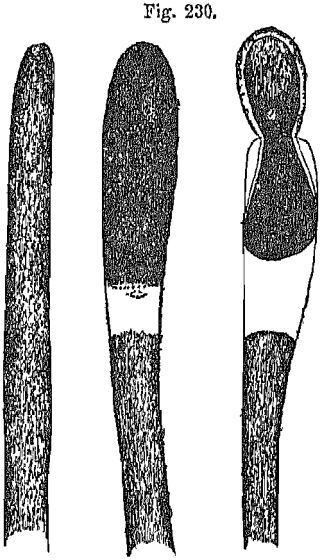
Are large, brown or olive-coloured seaweeds of a cartilaginous texture; they are found attached to rocks or other Algæ by simple or lobed discoid bases. The thallus branches dichotomously; the ramifications all lie in one plane. The brown pigment can be extracted by cold fresh water. The tissue frequently becomes hollowed out into air-cavities which serve as swimming-bladders.

The antheridia and oogonia are formed in spherical hol-

lows termed *conceptacles*. The oospheres are set free by the bursting of the oogonia, and are fertilized outside the plant by the antherozoids. Sometimes the antherozoid are present in the same conceptacles as the oospheres; sometimes they are borne on a separate plant. The antherozoids are each provided with two fine cilia.

The Fucaceæ are universally distributed, especially on rocks between tide-marks or in deep water buoyed up by their vesicular floats. Their chief value is as a source of iodine, which is extracted from the ashes. *Sargassium baccíferum* forms the celebrated "gulf-weed" in the Atlantic Ocean; this species is also to be found in the Indian Ocean as well as *S. vulgare*, Ag., and *S. illicifolium*, Turner, &c. In the genus *Asperococcus*, the thallus is tubular, and the clusters of spore-cases are mixed with filaments. The genus *Mesogloias* has the thallus much divided and thread-shaped. Other genera are: *Sphacelaria*, *Fucus*, &c.

Fig. 230.



Escape of a swarmspore of an *Œdogonium*.

Œdogonieæ.

The Œdogonieæ include at present only the two genera, *Œdogonium* and *Bulbochæte*. They are filamentous Algæ, consisting, in Œdogonium, of unbranched rows of cells; in Bulbochæte, of branched rows. They are mostly attached to the submerged parts of other plants.

The reproduction of the Œdogonieæ takes place by asexual swarmspores, and by oospores produced sexually. The oogonium is a cell of the filament itself. The mother-cells of the antherozoids are cells of the filaments, similar to the vegetative ones, but shorter and contain less chloro-

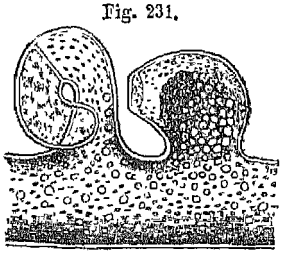
phyll; in most species, each of these cells divide into two special mother-cells, each producing one antherozoid. The antherozoids are very similar in form to the swarmspores, but much smaller; their motion due to cilia is also similar. The sexual plants are either monœcious or dicœcious.

Alternation of generation takes place in the following manner: the oospores formed by the fertilization of the oosphere by the antherozoids, after remaining at rest for a considerable time, forms asexually usually four swarmspores, from which again similar ones proceed until the series of them is closed by a sexual generation. *Œdogonium scutatum* is usually to be found in any stagnant fresh water.

Siphoneæ

Are found in fresh and salt water; they consist of a large single tubular, often branched, cell. The genus *Vaucheria* is the best known representative of this order. The thallus of Vaucheria is often several inches or a foot long, developing on damp shady earth or in water.

Fig. 231.



A portion of a plant of *Vaucheria*, showing an antheridium and an oogonium.

Besides the occasional multiplication by the separation of branches, reproduction is also brought about by asexual spores and by sexually produced oospores. All the species of Vaucheria are monœcious, and the two kinds of sexual organs are mostly found very near together. The antheridia are hook-shaped cells (see Fig. 231). The oogonia are spherical cells, formed close to the antheridia in which the oosphere originates by rejuvenescence. The process of vegetation in the genus *Botrydium* approaches very near to Vaucheria.

The marine genus *Caulerpa* forms from its single large cell, creeping stem-like structures which grow at their apex, with descending branched rhizoids and ascending leaf-like branches.

Conjugatæ

Are distinguished from all other Algæ by their reproduction by the process of conjugation (see page 259). The cells of the Conjugatæ are distinguished by the most various configurations and the beautiful arrangements of the masses of chlorophyll. In *Spirogyra* it occurs in parietal spiral bands. See *S. adnata, S. elongata, S. subæqua, S. nitida,* and *S. decimina.* In *Zygnema* it is arranged in radiate bodies, as in *Z. insigne.*

The *Desmideæ* belong to this order; they occur in all quiet pools of pure water, at the bottom, or adhering to other plants. The principal genera are: *Closterium,* Nitzsch; *Cosmarium,* Menegh; *Desmidium,* Agh., &c.

The *Diatomeæ* are nearly allied to the Desmideæ, but are readily distinguished from these and other unicellular Algæ by the possession of an epidermal covering of silex, which renders their form indestructable by the ordinary agents of decomposition; they are all exceedingly minute; and many of them are cosmopolitan (see Synopsis of the British Diatomaceæ, Smith).

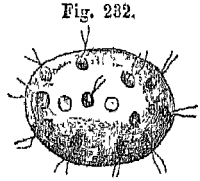
Diatomes are found in enormous numbers at the bottom of salt and fresh water attached to the submerged parts of other plants. Besides the ordinary rotation of protoplasm in their interior, they exhibit a creeping motion.

Some of the common Indian genera are: *Cyclotella,* Grun; *Coscinodiscus,* Ehrb.; *Achnanthes, Synedra,* Ehrb.; *Nitzschia,* Rab.; *Navicula,* Bory; and *Pleurosigma,* Grun.

Volvocineæ

Are unicellular microscopic plants, which during the whole of their vegetative period live socially in colonies or singly; they are almost continually in motion, interrupted only by certain periods of repose. The motion, as is usually the case in swarmspores, being caused by two cilia.

Fig. 232.



A family of Pandorina, the cilia project free into the water, and produce by their vibrations rotating and progressive movement of the whole family.

The social species are, however, distinguished from swarmspores by the cells being surrounded, while in

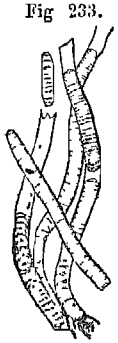
motion, by a membrane of cellulose through which the cilia project free into the water. These curious and beautiful objects are found abundantly in old tanks.

Protococcus, a genus of unicellular Algæ, but imperfectly known, is usually referred to this family; these plants are found abundantly in the mud, where rain water collects and in similar situations. They vary in colour from bright green to bright red. They multiply with great rapidity by cell division. *Protococcus cohærens* is very common on walls of buildings exposed to the weather; hardly are the walls whitewashed, when they again turn black, being covered by this Protococcus. *P. vulgaris* is also a common species.

Cyanophyceæ

Comprise a large number of minute organisms, including the sub-orders Oscillatoriæ, Nostocaceæ, Chroococcaceæ, Rivularieæ, and Scytonemeæ. The *Oscillatoriæ* (see Fig. 233) are microscopic filamentous structures, composed of continuous tubular sheaths enclosing a green or brown gelatinous matter marked by transverse striæ; the extremities of the filaments vibrate like a pendulum or with a slightly vermiform oscillation, whence the name of the group. *Oscillaria amphibia* may be frequently found forming slippery layers (of about one-eighth line thickness) on brick steps leading to tanks, &c., also submerged or near the surface of the water.

Fig 233.



Free thread-shaped rows of cells of *Oscillatoria*.

The *Nostocaceæ* are plants formed of thread-like or moniliform rows of cells, usually simple, rarely branched. The filaments are enclosed in gelatinous sheaths, by the deliquescence of which they are often united into large colonies which form either roundish or membranous wrinkled masses [Nostoc, see Fig. 234]. *Nostoc gregarium*, Thuret, occurs commonly submerged in tanks.

Fig. 234.

Wrinkled mass of *Nostoc* formed of thread-shaped cells enclosed in gelatinous sheaths.

The *Chroococcaceæ* are unicellular, and agree with the Nostocaceæ in their tendency to associate in slimy masses, the difference lies in their cells not being united into filaments.

FUNGI.

The *Fungi* form the second parallel division of Thallophytes (see abstract, page 257); their vegetative elements consist of cellular filaments, destitute of chlorophyll, which rarely branch dichotomously, more usually by lateral shoots, and which grow only at their apices; these elementary constituents of Fungi are called *hyphæ*. It is only in the Phycomycetes, a transitional group between Algæ and Fungi, that the entire vegetative portion of the Fungus consists of a single undivided cell.

The hyphæ either run parallel to one another, or their numerous ramifications are interwoven in various ways.

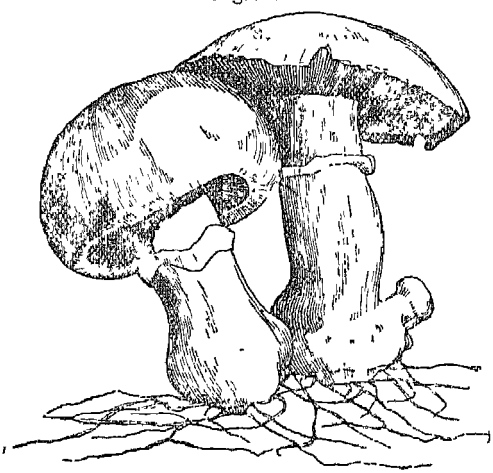
When these textures are very dense, they assume the form of a parenchymatous tissue, which is known as pseudoparenchyma; this tissue is especially developed in the larger Fungi, and can be well seen by boiling a portion of the receptacle of Polyporus in very dilute nitric acid and examining a section of it under the microscope.

The cell-walls of Fungi consist of a kind of cellulose; and the cells contain a characteristic fatty oil, but neither nucleus, chlorophyll or starch. Calcium oxalate is usually found on the surface of the hyphæ of Fungi. The absence of starch is not immediately connected with the want of chlorophyll. Since phanerogamic parasites like cuscuta (see page 159) and orbanche (see page 164), although they form no chlorophyll, yet contain abundance of starch.

Since Fungi do not form chlorophyll, they require for their nourishment the previous formation of an organic substance: many of them, therefore, are saphrophytes growing on dead organic substances; others are parasites, growing on living animals or plants; others again are endophytes, living in other organisms; only a few are epiphytes, living upon them. *Saprophytes* allied to the Schizomycetes are the cause of the phenomena of fermentation, decay, and putrification.

The whole process of development of a Fungus may be divided into two periods: First, from the spore a *mycelium* is produced, which consists either of simple filaments or loose flocculent expansions or compact tuberous masses (sclerotia); these last are not peculiar to any particular group of Fungi; but occur in species of the most different groups, like bulbs and tubers among Phanerogams. Second, from the mycelium arises the *receptacle*, on which the spores are developed; it is usually the most conspicuous part of the Fungus; the receptacle varies greatly in its external form, and is usually produced above ground. Thus the whole of the mushroom developed above ground is a receptacle.

Fig. 235.



A fungus (Mushroom): the root-like structure is termed a mycelium, the stem and cap form the asexual generation.

The production of spores is almost always limited to a particular part of the receptacle, the *hymenium;* these hymenia never produce anything but asexual reproductive cells, but the hymenium bearing body itself may be the product of a *sexual process.*

The mode of reproduction of Fungi is even more various than that of Algæ. Sachs states that "in those species the cycle of whose development is fully known, sexual and asexual reproduction occurs, or the latter is replaced by conjugation. In those cases where neither sexual reproduction nor conjugation has hitherto been observed, it may be assumed that our knowledge of the series of development is still incomplete, and that forms which are at present considered independent are really only mem-

bers of an alternation of generations (see page 255). It is important to note that it has been already ascertained that in many Ascomycetes, the receptacles which bear the Ascospores are the result of a sexual process which takes place in connection with the mycelium, so that the mycelium forms the first or sexual, the receptacle the second or asexual generation. In the Phycomycetes, on the other hand, the product of the sexual process is a *resting cell*, similar to what is found in many Algæ, while the origin of the receptacle of the Ascomycetes corresponds essentially with that of the Florideæ."

The systematic grouping of Fungi is still in process of continued change and improvement. Whole sections of genera of the earlier systems are now recognized as simple forms of development in the alternation of generations of other forms. For further particulars, see an Introduction to the study of Microscopic Fungi by M. C. Cooke, 1865; Handbook of British Fungi, Cooke, 1871; Sachs' Textbook, Bennet and Dyer's translation.

Basidiomycetes.

Although the largest and most beautiful Fungi belong to this order, yet their course of development is at present only very imperfectly known.

The *Basidiomycetes* (Basidium, a branch of the hyphæ on which the spores are developed, see Fig. 237) may be divided into the following three suborders: 1st Suborder *Tremellineæ* are Fungi of a gelatinous consistency; they are found growing on stumps of trees and on the ground; they collapse on drying; if, however, they are afterwards placed in water, they soon absorb it, and become again extended to their former size. *Tremella foliacea*, Fr., is of a rich claret colour, and of an irregular shape. *T. ferruginea*, Sm., and *T. protensa* are also common.

In the 2nd Suborder *Hymenomycetes* are included the commonest and best known of all Fungi (mushrooms). The structure, which is usually called the Fungus, is the receptacle (see Fig. 235). The hymenium (spore-bearing expansion of tissue) is spread over the under surface of the receptacle on projections of various forms which lie on the underside of the *pileus* or cap; on the stalk is some-

times found a ring or *annulus*, which is all that remains of a veil or covering (velum partiale) which united that part of the stalk with the outer edge of the cap or pileus,

Fig. 236.

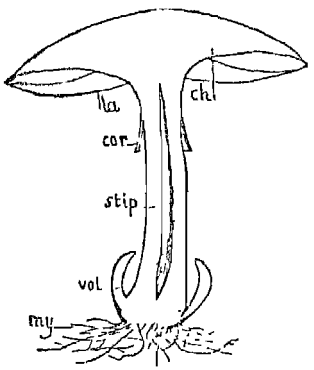
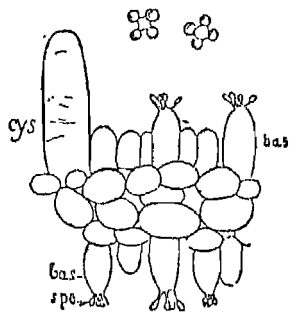


Diagram of an Agaricus; from the mycelium arises the receptacle (ch) supported on a stalk. (Stip) (la) the lamellæ (cor), the remains of the ruptured veil.

Fig. 237.



A portion of the hymenium of an Agaricus, showing (bas) Basidia on which the spores are formed; the sterile club-shaped cells are termed Paraphyses.

but was ruptured on the expansion of the latter, or sometimes the pileus and stalk are both enveloped in such a membrane (velum universale) or occasionally both are present. The species of Agaricini (mushrooms) are usually terrestrial in habit. In the *Polyporei*, the hymenium is spread over the cavity of tubes or pores. The texture of these plants is, as a rule, more cartilaginous than that of the Agaricini. The genus Polyporus includes a large number of species. *P. squamosus*, Fries., is familiar to most persons, growing like irregular brackets of great extent and considerable bulk at the base of stems of various trees. *P. versicolor* is also a familiar species, smaller than the last, but growing in great abundance, tier above tier, usually of an olive and yellow colour. The genus *Boletus* belongs to this group.

In the *Hydnacei*, the hymenium is spread over teeth or spines, which are soft, usually of the shape of an awl, and distinct at the base. *Hydnum zonatum* is a small fungus

of a reddish lilac hue, marked on the surface of the cap with darker zones; the centre becoming depressed. The *Merulius* group includes the plant known as dry root *M. lacrymans*, Fr.

The 3rd Suborder *Gasteromycetes* consists of fungi forming roundish angiocarpous receptacles consisting of an outer layer (peridium) enclosing masses of tissue on which are borne the hymenia. The Puffballs (*Lycoperdon*) are typical of this order. Other genera are: *Clathrus*, *Exidia*, *Geaster* (earth stars), *Bovista*, &c.

Æcidiomycetes.

The best known species of this order is *Puccinia Graminis*, Pers. (corn-mildew); it occurs on the leaves and culms of cereals and grasses, and is very common, and injurious to the plant. Its development not only shows a distinct alternation of generation, but that peculiarity by which one generation of a parasitic fungus is developed exclusively on one host, while another stage of development of the same species occurs only upon a different host. The term æcidium (cluster cups) is used to designate a particular form of fruit, in the cycle of development of Puccinia.

The æcidia (rust) are always developed on living plants, most commonly on the foliage leaves, usually on the under surface; leaves infected by these parasites present a singular appearance as if sprinkled with red dust. When examined closely small orifices are seen scattered over the under surface of the leaves; these cups (æcidia) appear to have burst through the epidermis of the leaves, and elevated themselves above its surface, with the lower portion attached to the substratum beneath; these cups are the fungi, the red dust the spores. The spores from these æcidia germinate beneath the epidermis of the leaves and stems of grasses, and were at one time considered as a distinct genus of Fungi, under the name—*uredo*.

The cycle of development is briefly this: from the resting spore a very minute mycelium (promycelium) is produced, and this usually divides into four cells, from each of which a minute cell (sporidium) is developed. On finding their way to a host (leaves of Berberis, for example) these spori-

dia germinate and their mycelium permeates the tissue, eventually developing fructifications (æcidia) on the under surface of the leaf and spermogonia on the upper surface. The spores which are formed on finding their way to a grass germinate, and form a mycelium in its tissue, and this produces two kinds of reproductive spores; one kind (the uredo spores) are 1-celled and germinate at once; the other (teleuto spores) are more than 1-celled and constitute the resting spores. To this order belongs *Ustilago carbo*, the smut of cereal grains. *U. segetum*, Ditin. (corn smut), occurs on the ears of cereals and grasses, and is very common.

Ascomycetes.

The Ascomycetes comprise a greater number of forms than any other order of Fungi. The common characteristic by which they are connected is the asexual formation of the spores in the interior of sacs (asci) by free cell formation. An alternation of generation has been clearly recognized, in so far as the receptacles in which the ascospores are produced, owe their origin to sexual union, which takes place on the mycelium. These fungi grow chiefly on the dead parts, or remains of plants, on living plants, or organic solutions.

The Ascomycetes may be divided into five suborders—*Tuberaceæ, Pyrenomycetes, Discomycetes, Erysipheæ*, and *Lichenes*.

The *Tuberaceæ* are fungi consisting of roundish tuberous bodies, usually found growing underground, and often surrounded by a branched mycelium; they may at first sight be easily confounded with the Gasteromycetes. The truffle (tuber) belongs to this order.

The Suborder *Pyrenomycetes* consists of fungi growing usually on dead organic bodies, and on living plants, and forming round or flask-shaped receptacles termed *perithecia*, which usually produce eight spores formed simultaneously. The perithecia usually open outwards by a small orifice, the internal cavity of which is lined by the soft hymenium. When the ascospores germinate, they produce a mycelium on which are formed: 1*st, conidia*; then 2*nd, spermatia*, enclosed in spermogonia;

and 3*rd*, *stylospores*, formed in the interior of *pycnidia*. Any of the members of these series may, however, be wanting, except the perithecia. The fungus Claviceps purpurea, which produces ergot, belongs to this suborder. Its development and structure is very complicated. Other genera are: *Sphæria*, Berk., which has the appearance of stains or dots of every shade of brown: *Xylaria*, Hill: *X. hypoxilon*, Ehrb., is common everywhere; it has a charred appearance; the thallus is sometimes simple, sometimes branched: *X. polymorpha*, Pers., is club-shaped; it is black and heavy, and looks like charred fragments of wood on the decaying stump on which it is usually found.

The *Discomycetes* live on dead organic bodies; they are distinguished from the Pyrenomycetes mainly by the hymenium being superficial. This suborder includes Peziza, enormously rich in species; they are beautiful fungi of a cup-shaped form; the hymenium is spread over the inside of the cup. *P. aurantia*, Pers., is of a pale orange colour on the outside; the plants grow in clusters: *Geoglossum glabrum*, Pers., is a black tongue-shaped fungus. Other genera are: *Phacidium*, Fr.; *Phytisma*, Berk.; and *Bulgaria*, Fr.

The Suborder *Erysipheæ* (mildews) consist of fungi growing on the surface of living plants and dead organic bodies; they are especially abundant on preserved fruit. These fungi are sometimes included under the Suborder Pyrenomycetes.

The suborder *Lichenes* are the best known Ascomycetes, and until very recently they were thought to occupy a position in the vegetable kingdom, equal in importance to that held by the Fungi and Algæ; but the researches of some distinguished botanists show that they are Ascomycetes belonging to the suborders Pyrenomycetes and the Discomycetes, parasitic, or consorted with Algæ of the Chroococcaceæ, Nostocaceæ, Palmellaceæ, etc.; this mutual parasiticism, if it may be so termed, appears to be beneficial to both organisms.

The green parts (*gonidia*) of Lichens contain chlorophyll, and are algoid bodies. From these Algæ the hyphæ of the fungal parasite extract nourishment for their own use. This theory has been confirmed by the production of a perfect

lichen, *Collema glaucescens*, by sowing its spores on the Alga *Nostoc lichenoides*; of the two components, the fungus is the superior, both in bulk and nature, and it is for this reason that the lichens are classed as Ascomycetes.

The spores of Lichens are produced in asci, which are formed in superficial cup-shaped receptacles, termed apothecia in the Discomycetes; perithecia in the Pyrenomycetes. Lichens are likewise reproduced by *soredia* (clusters of gonidia), which surrounded by a weft of hyphæ becomes detached from the thallus and grow into new thalli.

The Algæ hosts (gonidia) belong to the orders Chroococcaceæ, Nostocaceæ, and Palmellaceæ, &c. The fungi themselves have not been found in any other form than as parasites or Algæ.

The greater number of lichens are found as incrustations on damp ground, on the bark of trees, and on stones. The thallus of lichens can be dried, so as to be pulverized, without losing its vitality. The following abstract shows at a glance one of the latest classifications of lichens:

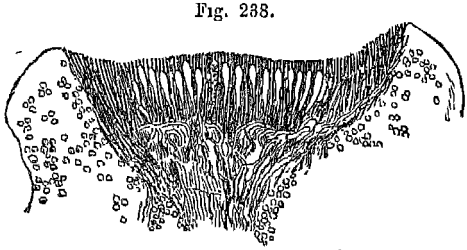
- LICHENS...
  - HETEROMEROUS— (Gonidia arranged in one layer.
    - FRUTICOSE— (Thallus attached only at one spot, and rising from it in the form of a shrub. Ex.: Usnea.)
    - FOLIACEOUS— (Thallus in the form of flake-like expansions often curled, which can frequently be detached from the substratum.)
    - CRUSTACEOUS— (Thallus in the form of incrustations. Ex.: Graphis.)
  - HOMŒOMEROUS— (Gonidia and hyphæ about equally mingled.)
    - GELATINOUS— Ex.: Collema, Leptogium, &c.
    - NON-GELATINOUS.

The disposition of the gonidia and hyphæ in a thallus may be such that those two structures appear about equally mingled; the thallus is in this case called *homœomerous*, or the gonidia are arranged in one layer, the

hyphæ being then separated into an upper and an under layer; such lichens are termed *heteromerous.*

Heteromerous lichens may be divided into fruticose, foliaceous, and crustaceous. Homöomerous lichens may be divided into gelatinous and non-gelatinous.

Fig. 238.

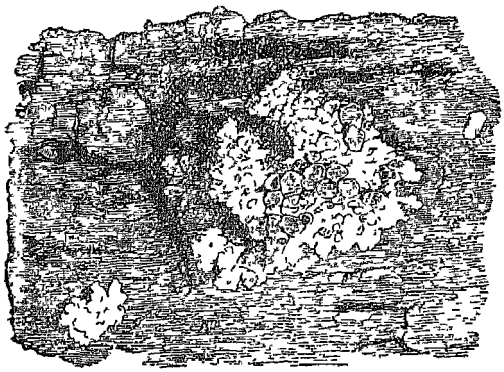


Vertical section through the middle of a young apothecium of *Lecanora* (after *Thomé*).

In the fruticose lichens, the cortex commonly constitutes a layer of uniform thickness round the thallus. The genus *Cladonia* is usually found growing on the ground. *Cladonia furcata,* Hoffm., has a brownish hue, and its branches are simple or only once forked. *C. rangiferina,* the reindeer lichen, is of a whitish colour; the form resembles that of a miniature tree, with round, sessile receptacles; it can endure almost any amount of heat and cold; it often grows to the height of 8 or 10 inches. In the genus *Stereocaulon,* the apotheciæ are flat. The genus *Usnea* is a very attractive one; the sections of the thallus are round, branched, and drooping. The long pendant Usneas are very characteristic of the upper forests above Darjiling. *Usnea barbata,* Fr., or the hairy Usnea, is jointed, very slender and long, and hangs like bunches of hair from the trees. *Alectoria jubata,* Ach., is usually found growing on the branches of coniferous trees, at high elevations in the Himalayas; the sections of the thallus are branched and are of a dark-brown colour. The genus *Ramalina* grow on decaying branches; and resemble diminutive shrubs. The most important species of the genus *Cetraria* is *C. islandica,* Ach., one of the nutritive lichens; it grows in upright olive-brown tufts; the thallus is paler on the underside than on the upper, and with a fringe of dark hairs; it grows most luxuriantly and plentifully in high latitudes. *C. stracheyi,* Bab., and *C. reticulata,* Kiplh., are also to be found in the Himalayas. The genus *Roccella,* from which litmus is obtained, belongs to this group.

In the foliaceous lichens, the cortex is usually different on the upper surface, which is exposed to the light, from the under surface, which is shaded by the thallus. The genus *Solerina* contains but two species; its characteristics are the orbicular apotheciæ and woolly veins. *S. crocea*, Ach., is of a yellowish green colour; the sunken apotheciæ are chestnut-coloured; it grows on ground, on the top of mountains. The genus *Sticta* has depressed dots on the under surface of the thallus, which is large, lobed downy beneath and free from the substratum except at the base. *S. pulmonacea*, Ach., is one of the handsomest of the lichens; the colour varies from a light-green to an olive-brown. The genus *Parmelia* contains some handsome and showy species. *P. caperata* is a handsome lichen, pale-yellow above, dark-brown and hairy beneath. *P. perlata* is of a silver-gray colour. *P. saxatilis* is of a darkish-brown colour, lighter towards the margin. The genus *Lecanora* contains a large number of species. From *L. tartarea*, the purple die called cud-bear is obtained. *L. esculenta*, of Tartary, presents the strange anomaly of a free lichen, unattached to wood, stone, or earth, and drawing its entire nourishment from the air The genus *Peltigera* also belongs to this group.

Fig. 239.



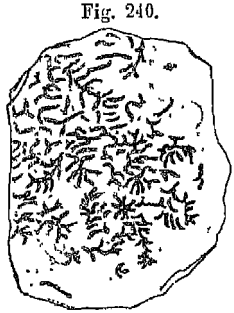
A lichen (Parmella) with a portion of the bark of the tree from which it was taken; in the hollow cup-like structures are formed the spores.

The thallus of the crustaceous lichens presents an affinity to that of the latter group in being fixed to the substratum by capillary or bristle-like rhizoids, so that it cannot be removed without injury. The genus *Lecidea* comprises a large number of species; the thallus is somewhat leafy and the apothecia are salver-shaped; the substance of the

thallus radiates in a regular form round the margin. *L. lutea* is of a pale-yellow colour; the apothecia being of a darker shade. In the genus *Arthonia*, the crust is thin and spreading and the apothecia round and sessile. These lichens form greyish stains dotted with tiny specks of brown or black upon trees. Other genera are: *Verrucaria* (the wartlichens), *Bœomyces*, *Pertusaria*, &c. The Pictorial lichens form thin patch-like incrustations on stones, and on the bark of trees; the chief peculiarity of their thallus consists in the nature of the gonidia, which are often united into rows of cells, increasing in length by the division of the terminal cell. There are two genera—*Opegrapha*, Pers., and *Graphis*. *Graphis scripta*, Ach, is to be found everywhere growing on the stems of trees (see Fig. 240).

The thallus of the gelatinous lichens has a leaf-like or arborescent form, or consists of granules, which constitute an incrustation. When dry, it is cartilaginous or brittle, and then absorbs water eagerly, swelling up into a gelatinous body; the gonidia lie in an apparently homogeneous jelly-like tissue. *Collema* is a typical form of these lichens. The genus *Leptogium* is also characteristic of this group. (For determination of genera and species of lichens, see Leighton's Lichen Flora, 1872; also see list of authors cited, page 574, Introduction to Cryptogamic Botany by Berkeley, 1857.)

Fig. 240.



Graphis scripta.

Phycomycetes.

The Phycomycetes may be divided into two suborders—the Saprolegineæ and the Peronosporeæ. The Saprolegineæ are fungi growing for the most part in water and chiefly on the bodies of putrefying insects, covering them completely with radiating cells; the contents of the oogonia are fertilized by the antheridia, which grow out in the form of tubes and pierce the oogonium to fertilize the germ-cell. The oospores, in germinating, produce a mycelium, which bear first asexual zoosporangia, and later the sexual organs; from the zoosporangia are produced zoo-

spores or swarmspores, which germinate and form a mycelium, from which arise again zoosporangia, and later the sexual organs; the sexual individuals are sometimes monœcious, sometimes dicœcious.

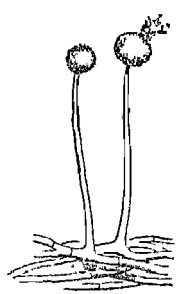
The Peronosporeæ are fungi parasitic on living Phanerogams, inducing in them speedy decay; they have a strong resemblance to the preceding suborder: the mycelium, which ramifies within the host plant, first bears the conidia (asexual reproductive organs) on branches, which in Peronospora protrude from the stomata of the plant on which they grow; in the genus *Cystopus* they are club-shaped, and form a hymenium beneath the epidermis: in some species the spores are not immediately capable of germination except when in contact with water, as for instance, drops of dew or rain; they then develop zoospores. *Peronospora infestans* is the cause of the potato disease, and *P. arborescens* is the cause of the poppy disease in India.

Zygomycetes.

The Zygomycetes are represented by the *mucorini*, which are fungi, growing on organic solutions, and consist of a densely branching mycelium, which bears both sexual organs and asexual sporangia; the root-like branches afterwards become multicellular by the formation of septa.

Mucor mucedo (see Fig. 241) infests dead or dying parts of plants, especially fleshy fruits, which quickly decay in consequence of its attacks; each of the ascending branches bears a sporangium within which numerous small spores arise; which are set free by the bursting of the wall of the sporangium; the zygospores (see page 259) are formed beneath the white felt-like texture of the mycelium filaments. *Penicillium glaucum* commonly appears on articles of food that have been kept for a few days. It presents, when examined under the microscope, the appearance of a miniature tree; the stem is simple, but bears at its summit a number of branches, resembling strings of beads.

Fig. 241.



Mucor mucedo showing mycelium bearing two sporangia.

Myxomycetes.

The Myxomycetes include a numerous group of organisms, which in many respects differ widely from all other vegetable structures, but in the mode of formation of their spores, stand nearest to Fungi. Their cells are without a cell-wall during the whole period of their vegetation and assimilation of food, and do not combine into a tissue; they live on decaying and rotting vegetable substance, such as tan, rotten stems, &c. When they reach the reproductive condition, the whole of the protoplasm becomes transformed into sporangia, or large receptacles. These sporangia are provided with a cell-wall, which varies in colour according to the species. The sporangia are filled with numerous spores, usually accompanied with thin wall tubes, opening one into the other; when the sporangium ruptures, the expulsion of the spores is assisted by these tubes (*capillitium*).

When a spore is saturated with water, it opens, and the whole of its protoplasmic contents escape as a roundish naked mass; but after some minutes, it assumes another form, becomes long and pointed at one end, where it is provided with long cilia; it is endowed either with a rotary motion, or creeps along, changing its form like an amœba (animal organism); these swarmspores multiply by division, but on the second or third day they cease dividing, and unite, two or more of them coalescing into a homogeneous protoplasmic substance, the *plasmodium*, also endowed with an amœba like motion. The plasmodia pass into a resting state, and becomes encysted, when the weather is dry, and can remain in this condition for months without losing their power of life. When the weather is moist and warm, the plasmodium again creeps out of these cysts.

Arcyria punicea, Pers., grows in abundance on dead wood; the spores are of a bright red colour. Other common Myxomycetes are: *Lycogala epidendron*, Fr.; *Reticularia entozantha*, Berk.; and *Cyathus Hoorkeri*, &c.

Saccharomyces.

The Saccharomyces are the yeast fungi, which cause the alcoholic fermentation of the saccharine juices of plants,

or of artificial solutions which contain sugar in addition to nitrogenous substances. These fungi consist of small roundish or ellipsoidal cells, which multiply by budding for an indefinite time, giving off bubbles of carbonic dioxide; the yeast plant also multiplies by endoginous segmentation of the cells; the protoplasm dividing into four subdivisions, around each of which a new cell-wall is formed; each individual is an ordinary vegetable cell, usually containing a vacuole, but no nucleus; the cells are either solitary, or associated in heaps or strings; their walls are formed of a modification of cellulose (the substance of which all vegetable cell membranes are formed), and mixed with which are minute quantities of sulphur, phosphorus, potassium, magnesium, and calcium.

Within the cells exist nitrogenous matter, in the condition of protoplasm, fatty matter, and water; the properties which determine these objects to be plants, are their power of forming protein, cellulose, and fat, out of a nutrient fluid of definite chemical composition, such as Pasteur's solution, which contains potassium phosphate, 2 parts; calcium phosphate, 2 parts; magnesium sulphate, 2 parts; ammonium tartrate, 100 parts; cane-sugar, 1,500 parts; and water, 8,394 parts.

Saccharomyces cerevisiæ can be easily seen by adding a small quantity of the juice (Taree) of Phœnix sylvestris (Khajoor) to a saccharine solution, letting the solution stand for about twenty-four hours, and then examining it with a one-eighth object glass.

Schizomycetes.

The Schizomycetes are the lowest forms of vegetable life known; they are usually present in great abundance whenever putrefying organic matter is found. All these organisms are characterized by the ease with which they break up into their separate cells, as soon as they come into contact with the atmosphere, from which circumstance they have received their name. They include the forms known as Bacteria, Vibriones, Spirilla, Bacillus, &c.; these organisms are placed among Fungi, as they show an analogy to them in their mode of life, since they obtain their nutriment from organic substances. Mr. D. D. Cunningham,

who has devoted considerable time to the study of these organisms, has forwarded to me the following note on Schizomycete forms common in the neighbourhood of Calcutta :—

"In regard to Schizomycete forms common in this neighbourhood, any number of form species of Bacterium, Basillus, and Spirochæte are to be obtained in all sorts of media. Various Bacterial and Basillar forms constitute a great mass of the contents of the lower portions of the intestinal tract in man and other animals, and as they are constantly liable to obtain access to the intrinsic nutritive fluids of the body, may often be detected in small numbers in these, quite apart from the existence of any morbid conditions in the host, but ready at once to undergo farther development and multiplication if, under any circumstances, conditions arise favouring them as compared with the intrinsic living units of the organism in the struggle for existence."

DIRECTIONS FOR COLLECTING BOTANICAL SPECIMENS.

"Specimens should, if possible, be gathered in fine weather, and free from external moisture. In selecting them, care should be taken to have the plants in a perfect state of growth, with all the parts from which characters are taken. The entire plant, with roots, stems, leaves, and flowers, when practicable, should be preserved; and the roots should be washed before being put into the box of the collector. In the case of very large herbaceous plants or shrubs or trees, portions only can be taken. These should always be carefully selected so as to exhibit the characteristic organs. In the case of tall and slender Gramineæ and Cyperaceæ, the specimens may be folded once or twice backwards and forwards, and thus suited to the size of the paper used in forming the herbarium; and the folds may be secured during drying by being pushed into slits in small strips of paper. Ferns and many other tall plants may be preserved entire in the same way. A thick branch or stem should be split, so as to allow of pressure being applied; and very thick roots, as well as bulbs and corms, may be similarly treated."—*Balfour.*

One of the best and most interesting methods of impressing the characters of plants on the memory is to carefully botanize a selected route, then to make dissections of the different parts of the plants found, dry them separately, and afterwards glue them on paper in their proper order.

The plants found during a four hours' excursion of this kind on the 24th October 1880 between the Naihati railway station on the Eastern Bengal Railway and the village of Bhatparah, a distance of about four miles, are here given as an example (the names of all the plants found are given below, whether in flower at the time or not).

Microscopic and other plants not readily diagnosed should be preserved for further examination:—

Ranunculaceæ.

Naravelia zeylanica, D. C. (Chhágal báti).

Anonaceæ.

Anona squamosa, L. (Atá); Anona reticulata, L. (Nona).

Menispermaceæ.

Tinospora cordifolia, Miers (Gulancha).

Nymphæaceæ.

Nymphæa lotus, L.

Bixaceæ.

Bixa orellana, L. (Latkan).

Cruciferæ.

Sinapis dichotoma, Roxb. (Surshá).

Capparidaceæ.

Gynandropsis pentaphylla, D. C. (Hurhuriyá). Capparis horrida, L.

Moringaceæ.

Moringa pterygosperma, D. C. (Sajiná).

Malvaceæ.

Sida humilis, Willd; Sida rhombifolia, L. (Bárjálá); Bombax malabaricum, D. C. (Shimul); Hibiscus vitifolius, L. (Bánkápás); Hibiscus esculentus, L. (Dhenrus).

Aurantiaceæ.

Limonia pentaphylla, Retz (Ash-shoura); Citrus acida, Roxb. (Nebú); Ægle Marmelos, Corr. (Bel); Citrus decumana, L. (Batavi-nebú); Murraya exotica, L. (Kamini).

Meliaceæ.

Azadirachta indica, Ad. Juss. (Nim); Cedrela toona, Roxb. (Tun).

Oxalidaceæ.

Oxalis corniculata, L. (Amrúl).

Vitaceæ.

Vitis pallida, W. and A. (Goáliya latá); Vitis glauca, W. and A. (Gargoáliya); Leea crispa, L. (Ban chálita).

Rhamnaceæ.

Zizyphus Jujuba, Lam. (Byar); Zizyphus oenoplia, Mill (Shyákul).

Anacardiaceæ.

Odina wodier, Roxb. (Jiol); Mangifera indica, L. (Am); Spondias amara, Buch. (Amrá).

Sapindaceæ.

Nephelium Litchi, L; Cardiospermum halicacabum, L. (Shibjhul).

Crassulaceæ.

Bryophyllum calycinum, Salisb.

Leguminosæ.

Suborder Papilionaceæ.

Tamarindus indica, L (Tinturí); Dolichos lablab, L. (Shim); Dolichos sinensis, L. (Barbati); Cajanus indicus, Spreng. (Arar); Clitoria ternatea, L. (Níl-áparájitá); Phaseolus mungo, L. (Hali mug); Erythrina indica, Lamk. (Pálitá mandar).

Suborder Cæsalpiniæ.

Poinciana pulcherrima, L. (Krishna churá); Cæsalpinia Bonducella, Flem. (Nátá); Cassia Sophora, L. (Kál kásundá); Cassia fistula, L. (Sondálu); Cassia alata, L. (Dádu mardan); Bauhinia variegata, L. (Rakt kánchan).

Suborder Mimoseæ.

Acacia tomentosa, Willd. (Sálsúin bábala); Acacia Sirissa, Buch. (Sirish).

Myrtaceæ.

Eugenia Jambolana, L. (Kála jám); Psidium Guyava, L. (Peyárá).

Combretaceæ.

Terminalia Catappa, L. (Bádám).

Cucurbitaceæ.

Momordica charantia, L. (Karalá); Luffa pentandra, Roxb. (Dhundul); Lagenaria vulgaris, Ser. (Láo); Trichosanthes cucumerina, L. (Banpatol); Benincasa cerifera, Savi (Kumrá); Coccinia grandis, W. and A. (Tela kuchá).

Papayaceæ.

Carica Papaya, L. (Pepiyá).

Cactaceæ.

Opuntia Dillenii, Haw. (Nagphená); Cereus hexagonus, Haw.

Umbelliferæ.

Hydrocotyle asiatica, L. (Thal kuri).

Rubiaceæ.

Nauclea Cadamba, Roxb. (Kadam); Pavetta indica, L. (Kukur churá).

Compositæ.

Vernonia cinerea, Less. (Chhota koksim); Blumea lacera, D. C. (Bara koksim).

Plumbagineæ.

Plumbago zeylanica, L. (Chitta).

Ebenaceæ.

Diospyros embryopteris, Pers. (Gáb).

Asclepiadeæ.

Calotropis gigantea, R. Br. (Akánda); Dæmia extensa, R. Br. (Chhágal bánti); Hemidesmus indicus, R. Br. (Anantumul).

Apocynaceæ.

Vallaris dichotoma, Wall. (Haparmáli); Thevetia nereifolia, Juss. (Kaliká).

Jasmineæ.

Nyctanthes arbor tristis, L. (Sinalí).

Boraginaceæ.

Heliotropum indicum, L. (Hátsurá).

Convolvulaceæ.

Ipomœa sepiaria, Koen; Ipomœa reniformis, Chois. (Bhuin kámri).

Solanaceæ.

Solanum ferox, L. (Rám begun); Datura alba, N. E. (Dhuturá); Capsicum frutescens, L. (Lal-langká-marich); Solanum verbascifolium, L. (Aras).

Verbenaceæ.

Clerodendron siphonanthus, R. Br. (Báman-háti); Tectona grandis, L. (Segun); Vitex negundo, L. (Nishinda); Clerodendron infortunatum, L. (Bhaut).

Labiatæ.

Ocimum sanctum, L. (Tulsi); Leonotis Sibirica; Leucas linifolia, Spreng. (Halkasa).

Acanthaceæ.

Barleria dichotoma, Roxb. (Sádá játi); Justicia procumbens, L.; Justicia Adhatoda, L. (Bákas); Acanthus ilicifolius, L. (Hákuch-kánta); Ruellia ringens, Roxb. (Burigopáná).

Scrophularineæ.

Lindenbergia ruderalis, L. (Haldi basunta).

Casuarineæ.

Casuarina equisetifolia, Forst. (Jáu).

Euphorbiaceæ.

Ricinus communis, L. (Bheranda); Pedilanthes tithymaloides, Povi (Ráng-chitrá); Ricinus dicoccus, Roxb.;

Tragia involucrata, L. (Bichhati); Euphorbia antiquorum, L. (Tekátá-sij); Euphorbia ligularia, Roxb. (Mansásij); Jatropha multifida, L. (Croton, sp.); Trewia nudiflora, Spreng. (Pitall).

Ulmaceæ.

Celtis orientalis, L. (Jíbun).

Urticaceæ.

Ficus Carica, L. (Dúmúr); Ficus religiosa, L. (Ashwath); Artocarpus integrifolia, L. (Kántál); Urtica interrupta, L. (Lal bichhati).

Nyctaginaceæ.

Boerhaavia erecta, L. (Purná).

Chenopodiaceæ.

Basella alba, L. (Puin); Basella cordifolia, Lam. (Puin shák).

Amarantaceæ.

Amarantus spinosus, L. (Kántá nati); Amarantus gangeticus, L. (Denga); Deeringia indica, Spreng. (Ghol mohaní); Achyranthes aspera, L. (Apang); Alternanthera sessilis, R. Br. (Shanchi).

Polygonaceæ.

Polygonum lanigerum, R. Br. (Páni-marich).

Hydrocharideæ.

Vallisneria spiralis, L. (Jhangi); Hydrilla verticillata, Casp.

Scitamineæ.

Musa sapientum, L. (Kalá); Curcuma longa, L. (Haldí).

Dioscorideæ.

Dioscorea anguina, Roxb. (Kukur-álu); Dioscorea globosa, Roxb. (Chupri-álu).

Smilaceæ.

Smilax ovalifolia, Roxb. (Kumariká).

Commelinaceæ.

Commelina bengalensis, Kth. (Kánchará); Commelina communis, Kth. (Jatá kánchara).

Palmeæ.

Phœnix sylvestris, Roxb. (Khajur); Areca çatechu, L. (Supári); Cocos nucifera, L. (Nári-kel); Borassus flabelliformis, L. (Tál gáchh).

Aroideæ.

Colocasia antiquorum, Schott. (Kachu); Amorphophallus campanulatus, Bl. (Ol); Colocasia indica, Schott. (Mankachu); Typhonium Roxburghii, Schott. (Ghet-kachu).

Pistiæ.

Pistia stratiotes, L. (Tákápáná); Lemna polyrrhiza, L.

Cyperaceæ.

Cyperus rotundus, L. (Mutha); Scirpus plantagineus, N. E. (Chenchká).

Gramineæ.

Panicum hirsutum, Kön. (Jálgántí); Panicum, sp.; Saccharum officinarum, L. (Uk); Andropogon acicularis, Retz. (Chor kántá); Imperata arundinacea, Cyrill (Ulu); Cynodon Dactylon, Rich. (Durba); Bambusa arundinacea, Retz. (Bánsh).

Polypodiæ.

Pteris longifolia, L.; Adiantum lunatum, L.; Adiantum cordatum, L.; Nephrodium molle, Desv.

Bryaceæ.

Hypnum bryoides, L.; Tortula indica, Hook.

Jungermannieæ.

Jungermannia, sp.

Marchantieæ.

Marchantia polymorpha, L.

Characeæ.

Chara verticillata, Roxb.

Conjugatæ.

Spirogyra elongata.

Navicula calcuttensis, Grun; Cyclotella striata, Grun.

Volvocineæ.

Protococcus vulgaris; Volvox, sp.

Oscillatoriæ.

Oscillatoria brevis.

Basidiomycetes.

Polyporus versicolor, Zipp; Polyporus squamosus, Fries; Agaricus stillaticius, Berk.; Agaricus rubiætinctus, Berk., Agaricus semiglobatus, Batch.

Ascomycetes.

Suborder Lichenes.

Graphis scripta, Ach.; Pertusaria communis, D. C.; Parmelia perlata, Ach.; Bæomyces icmadophyllus, L.; Arthonia subvelata, Nyl.; Lecidea lutea, Dicks.

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